E. T. Jeffery.
Chicago

Feb 2/75.

THE

SEVENTH ANNUAL REPORT

OF THE

AMERICAN RAILWAY

MASTER MECHANICS' ASSOCIATION,

IN CONVENTION, AT CHICAGO,

May 12, 13, and 14, 1874.

CINCINNATI:
WILSTACH, BALDWIN & CO.,
RAILWAY PRINTERS AND MANUFACTURING STATIONERS,
Nos. 141 AND 143 RACE STREET.
1874.

AMERICAN RAILWAY

MASTER MECHANICS' ASSOCIATION.

OFFICERS FOR 1874.

PRESIDENT,

H. M. BRITTON, of Cincinnati.

FIRST VICE-PRESIDENT,

N. E. CHAPMAN, of Cleveland.

SECOND VICE-PRESIDENT,

W. A. ROBINSON, of Canada West.

TREASURER,

S. J. HAYES, of Chicago.

SECRETARY,

J. H. SETCHEL, of Cincinnati.

REPORT.

The Seventh Annual Session of the American Railway Master Mechanics' Association convened at Kingsbury Hall, Chicago, Illinois, May 12, 1874.

President H. M. BRITTON, Cincinnati and Whitewater Valley R. R., in the Chair.

N. E. CHAPMAN, Cleveland and Pittsburg R. R.....1st Vice-President.

W. A. ROBINSON, Great Western R. R., of Canada..2d Vice-President.

S. J. HAYES, Illinois Central R. R.........................Treasurer.

J. H. SETCHEL, Little Miami R. R.......................Secretary.

The session was opened at 9 A. M., with prayer by the Rev. Dr. McKown of Chicago.

The President—Gentlemen, I hold in my hand the minutes and proceedings of the last Convention. Is it your pleasure that they be received without reading?

On motion, the minutes were received and adopted without reading.

The President—The next business in order will be the calling of the roll, after which there will be an opportunity offered for all who are eligible and desire to become members, to sign the Constitution.

The Secretary then called the roll, and the following members were found to be present:

NAME.	ROAD.	ADDRESS.
H. ANDERSON		51 Fifth ave., Chicago.
H. M. BRITTON	Cincinnati & Whitewater Valley	Cincinnati, Ohio.
A. W. BRITTON	Cincinnati & Whitewater Valley	Harrison, Ohio.
M. E. BROWN	Erie	New York city.
H. L. BROWN	Erie	Jersey City, N. J.
C. H. BROWN	West. Div. Del., Lackawanna & West	Utica, N. Y.
R. W. BUSHNELL	Burlington, Cedar Rapids & Minn	Cedar Rapids, Iowa.
WM. H. BRYANT		103 Jud st., Chicago.

NAME.	ROAD.	ADDRESS.
H. G. BROOKS	Brooks Locomotive Works	Dunkirk, N. Y.
H. L. COOPER	Hannibal & St. Joe	Hannibal, Mo.
N. E. CHAPMAN	Cleveland & Pittsburg	Cleveland, Ohio.
S. M. CUMMINGS	Pittsburg, Ft. Wayne & Chicago	Allegheny, Pa.
G. W. CUSHING	Late of Toledo, Wabash & Western	Fort Wayne, Ind.
FOSTER CHURCH	Troy & Boston	Troy, N. Y.
ROBERT CURTIS	Pittsburg, Cincinnati & St. Louis	Columbus, Ohio.
JOHN F. CROCKETT	Boston, Lowell & Nashua	Boston, Mass.
A. H. DeCLERCQ	I. & Great Northern	Hearne, Texas.
J. T. DEVINE	Wilmington & Weldon	Wilmington, N. C.
W. DUNCAN		Worcester, Mass.
WILSON EDDY	Boston & Albany	Springfield, Mass.
HENRY ELLIOTT	Ohio & Mississippi	East St. Louis, Mo.
J. U. EASTMAN	Nashville & Chattanooga	Nashville, Tenn.
C. L. EASTMAN	Concord	Concord, N. H.
JOSEPH ELDER	Rockford, Rock Island & St. Louis	Beardstown, Ill.
W. H. ELLIS	Philadelphia & Reading	Catawissa, Pa.
WM. FULLER	Atlantic & Great Western	Meadville, Pa.
CHARLES FELLOWS	Lake Shore & Tuscarawas Valley	Cleveland, Ohio.
J. S. FUNK	Northern Central	Marysville, Pa.
E. B. GIBBS	Louisville, Cincinnati & Lexington	Louisville, Ky.
CHARLES GRAHAM	Lackawanna & Bloomsburg	Kingston, Pa.
E. GARFIELD	Hartford, Providence & Fishkill	Hartford, Conn.
ALBERT GRIGGS	Worcester & Nashua	Worcester, Mass.
A. GOULD	N. Y. Central & Hudson River	Rochester, N. Y.
F. GOULD	Missouri, Kansas & Texas	Sedalia, Mo.
R. D. GRANT		
S. J. HAYES	Illinois Central	Chicago, Ill.
C. T. HAM	Buffalo Steam Gauge Company	Buffalo, N. Y.
W. S. HUDSON	Rogers Locomotive Works.	Paterson, N. J.
A. W. HIBBERD	Jefferson City Iron Works	Jefferson City, Mo.
C. W. HOLLISTER	Connecticut Valley	Hartford, Conn.
S. A. HODGMAN	Philadelphia, Wilmington & Baltimore	Wilmington, Del.
JACOB JOHANN	Toledo, Wabash & Western	Springfield, Ill.
J. A. JACKMAN	Chicago, Alton & St. Louis	Bloomington, Ill.
ROBERT KING	Charleston, Columbia & Augusta	Columbia, S. C.
SANFORD KEELER	Flint & Pere Marquette	East Saginaw, Mich.
B. H. KIDDER		Buffalo, N. Y.
H. A. LITTLE	2043 Tower street	Philadelphia, Pa.
T. V. LOSEE	Indianapolis, Bloomington & Western	Urbana, Ill.
J. N. LAUDER	Northern of New Hampshire	Concord, N. H.
J. LOSEY	Louisville, New Albany & Chicago	New Albany, Ind.
W. LININGER	Pittsburg, Virginia & Charleston	Pittsburg, Pa.

NAME.	ROAD.	ADDRESS.
FRED. C. LOSEY	120 Park avenue	Jackson, Mich.
THOS. LINGLE	Chesapeake & Ohio	Richmond, Va.
G. F. MORSE	Portland Locomotive Works	Portland, Me.
LYELL T. MEAD	West Wisconsin	Hudson, Wis.
J. McKENNA	Indianapolis, Peru & Chicago	Peru, Ind.
JOHN McVAY	Western of Alabama	Montgomery, Ala.
EZRA OSBORNE	Grant Locomotive Works	Paterson, N. J.
E. PIERCE	Pittsburg, Cincinnati & St. Louis	Dennison, Ohio.
S. M. PHILBRICK	Leavenworth, Lawrence & Galveston	Lawrence, Kansas.
C. R. PEDDLE	St. Louis, Vandalia & Terre Haute	Terre Haute, Ind.
G. H. PRESCOTT	Pittsburg, Cincinnati & St. Louis	Logansport, Ind.
T. B. PURVES	Western Division of Boston & Albany	Greenbush, N. Y.
GEORGE RICHARDS	G. Boston & Providence	Boston, Mass.
W. A. ROBINSON	Great Western	Hamilton, Canada.
W. D. ROBB	Elizabethtown & Paducah	Elizabethtown, Ky.
A. H. SOMERS	Pittsburg, Ft. Wayne & Chicago	Valparaiso, Ind.
J. SKIDMORE	Louisville & Nashville & Great Southern	Nashville, Tenn.
W. T. SMITH	Philadelphia & Erie	Erie, Pa.
MORRIS SELLERS	Air Brake Company	Pittsburg, Pa.
L. H. SELLERS	New Orleans, Jackson & Great North'n	Pensacola, Fla.
J. H. SETCHEL	Little Miami	Cincinnati, Ohio.
JAMES SEDGLEY	Lake Shore & Michigan Southern	Cleveland, Ohio.
W. M. STRONG	New York & Harlem	New York city.
H. N. SPRAGUE		Pittsburg, Pa.
N. SLINGLAND	Western	Hartford, Conn.
A. J. SANBORN	Indianapolis & St. Louis	Mattoon, Ill.
H. A. TOWNE	Northern Pacific	St. Paul, Minn.
L. N. TOWNE	Hannibal & St. Jo	Hannibal, Mo.
JOHN THOMPSON	Eastern	East Boston, Mass.
J. VAN VETCHEN	Erie	Meadville, Pa.
REUBEN WELLS	Jeffersonville, Madison & Indianapolis	Jeffersonville, Ind.
J. E. WIGGIN		Boston, Mass.
J. L. WHITE	Evansville & Crawfordsville	Evansville, Ind.
E. H. WILLIAMS	Baird & Co., Locomotive Builders	Philadelphia, Pa.
L. S. YOUNG	Cleveland, Columbus, Cincinnati & Ind.	Cleveland, Ohio.

ASSOCIATE MEMBERS.

NAME.	ROAD.	ADDRESS.
M. N. FORNEY	Railroad Gazette	New York city.
J. O. D. LILLY		Indianapolis, Ind.
F. B. MILES	Ferris & Miles	Philadelphia, Pa.
COLEMAN SELLERS		Philadelphia, Pa.

THE PRESIDENT—The Secretary will read Sections 1 and 2 of Article IV of the Constitution, which will explain who may become members of the Association.

ARTICLE IV.

SEC. 1. The following persons may become members of the Association by signing the Constitution, or authorizing the President or Secretary of the Association to sign for them, and pay the initiation fee of one dollar: Any person having charge of the Mechanical Department of a Railway, known as "Superintendents," or "Master Mechanics," or "General Foremen," the names of the latter being presented by their superior officers for membership.

SEC. 2. Civil and Mechanical Engineers, and others whose qualifications and experience might be valuable to the Association, may become Associate Members by being recommended by three active members. Their names shall then be referred to a committee, which shall report to the Association on their fitness for such membership. Applicants to be elected by ballot at any regular meeting of the Association, and five dissenting votes shall reject. The number of Associate Members shall not exceed twenty. Associate Members shall be entitled to all the privileges of active members excepting that of voting. Also, two Mechanical Engineers or the representative of each Locomotive Establishment in America.

THE PRESIDENT—All those persons who come under the heads of Superintendents of Machinery, General Master Mechanics, Master Mechanics, Foremen (with a letter from their superior officers), will now have an opportunity to sign our Constitution.

NEW MEMBERS.

NAME.	ROAD.	ADDRESS.
FRANK D. CHILD	Hinckley Locomotive Works	Boston, Mass.
R. O. CASSCADIN	Chicago, Rock Island & Pacific	Trenton, Mo.
H. V. FARIES	Atchison, Topeka & Santa Fe	Topeka, Kansas.
W. A. FIELDS	Portland & Oxford	Portland, Me.
L. FINLAY	Cairo & Fulton	Little Rock, Ark.
W. H. HIPPLE	Texas & Pacific	Marshall, Texas.
R. F. HURD	Peoria, Pekin & Jacksonville	Pekin, Ill.
J. A, HANGLIN	Kansas Pacific	Armstrong, Kansas.
E. T. JEFFREY	Illinois Central	Chicago, Ill.
J. D. JOHNSON	Chicago & Alton	Chicago, Ill.
G. S. KILBY	C. & P	Lyndonville, Vt.
J. J. LADD	Springfield & Illinois South-eastern	Pana, Ill.
J. C. MUNRO	St. Paul & Pacific	St. Paul, Minn.
CHARLES METZER	Louisville, Cincinnati & Lexington	Louisville, Ky.
C. R. MORRIS	Housatonic	Falls Village, Vt.
JOHN ORTTON	Great Western of Canada	Hamilton, Canada.

NAME.	ROAD.	ADDRESS.
T. W. PLACE	Illinois Central	Waterloo, Iowa.
G. W. STEVENS	Lake Shore & Michigan Southern	Elkhart, Ind.
L. B. SALISBURY	St. Louis & South-eastern	Mount Vernon, Ill.
H. SCHLACKS	Illinois Central	Chicago, Ill.
G. W. STRATTON	Pennsylvania Railroad	Altoona, Pa.
B. WARREN	St. Louis, Albany & Terre Haute, Belleville & Southern Illinois Division	St. Louis, Mo.
THOMAS WALSH	Mobile & Ohio of Lou. & Nash. Gt. South.	Memphis, Tenn.
W. L. WALLACE	Lake Shore & Michigan Southern	Buffalo, N. Y.
H. S. WALLACE	Columbus & Hocking Valley	Columbus, Ohio.
PHILIP WHITE	Cleveland & Pittsburg	Wellsville, Ohio.
T. B. WOODRUFF	Central of Iowa	Eldora, Iowa.
HORACE E. WOODS	Chicago, Rock Island & Pacific	Rock Island, Ill.
WM. WILSON	Chicago, Burlington & Quincy	Galesburg, Ill.

The President then delivered his annual address:

PRESIDENT'S ADDRESS.

Gentlemen of the American Railway Master Mechanics' Association:

For the seventh time it becomes my duty and pleasure to welcome our annual reunion. Each returning year has added to the strength of our numbers, to the vigor of our organization, and to the usefulness which has been the aim and object of our Society.

This Association was born of a new industry. Since its birth, the period during which the child still remains near the mother's knee has hardly elapsed, yet we can point with pride to what it has done. It has united what has become a profession. It has mingled the thoughts, the ideas, the experiments, and the ascertained results obtained by the members of this profession ; sifted them, culled what was good, thrown away the chaff, collated the facts, and given their benefits, so far as ascertained, to the world; so much yet remains to be done that the Society should boast of having accomplished very little.

At the opening of our Sixth Convention, a year ago, I took occasion to call your attention to the dangers that threatened the Railways in many of the States, in view of the hopes entertained by producers, living at great distances from the seaboard, of realizing

all the profits of an Eastern market for a Western product, through the medium of a railway.

Men not practical either in the art of building railways, or the business of operating them, held out this delusive hope to those from whom they desired to obtain the money to construct a road.

Such men made money in building the road, and little cared they whether it would be profitably operated or not.

I then called attention to the fact that more had been done with the machinery you represent than had been hoped for or deemed possible, and warned you that where seeming impossibilities had been accomplished there was danger that the really impossible would be attempted. The past year has been fruitful in financial disaster to the railways of the West. All that then seemed possible, and more, has happened, or is in daily progress of occurrence. The farmer, deceived into donating his money for the building of a railway, finding he has received no such benefit as he expected from its construction and operation, has become a Granger. The Granger has become a legislator, and rates of freight have been made by legislative enactment, without reference to the cost of transportation. Thus the framing of a practical railway tariff, the most difficult task to which the experienced railroad managers have to address themselves, has been solved by these legislators, by the passage of some general enactment, which has had but a few hours' consideration. A great variety of causes have combined to embarrass or bankrupt many of the railways of the country.

It becomes the duty of this Convention to examine into these causes, to ascertain, if possible, the measure of its own responsibility, and, so far as it has the power, to apply a remedy. The principal cause of the present non-paying condition of many of the railways is that the business has been overdone. This, professionally, we had no part in doing. It is one of the strange truths connected with railway business that the practical man is rarely consulted either as to the manner in which a road shall be constructed, or as to whether it will pay to operate it. But disaster always follows the overdoing of any business, and in that disaster we are involved.

Have we not had some share in increasing that disaster? Have we done all we might have done to avert it?

In building so many roads through sparsely-settled regions of our country, in building so many unnecessary and competing roads, great wrong has been done to legitimate railway enterprise. No railway can pay the interest on its cost when it is obliged to rely for its traffic on the simple, bulky farm products of the country through which it passes. The railway must connect city with city, or it must have a large manufacturing or mining interest on its line, to enable it to earn the interest on its cost. These facts are strikingly illustrated in the recent public statement of the earnings of some of our largest through lines, made in connection with a statement of the earnings of their feeders. These statements show that while the through line earns largely, the losses on the feeders absorb those earnings, and more. The through line connects city with city, manufactory and mine with the market for its product. Its passenger and freight business are profitable at reasonable rates. The feeder hauls freight only at a great cost in collecting and handling; while its passenger trains are almost always operated at a loss. The competing through line cuts every legitimate and reasonable rate both for freight and passengers, and reduces the whole business to a losing one. The overdoing of the business, then, by building feeders not self-sustaining, and parallel through lines not required for the transaction of legitimate business, is the great cause of the present distrust in all railway enterprise.

This overdoing of the business by constructing unnecessary roads is not all—the roads have not been well built. During their construction their financial affairs have not been honestly administered. The widespread disaster and distrust which now exist would be more easily overcome if this were not true. The roads have mostly been built from the proceeds of bonds, sold at a heavy discount, and by contractors who built for their own profit, so the bonded debt often represents more than twice the cost of the road, and the road itself has to be thoroughly rebuilt by those who operate it during the first few years of its existence. All this you know to be true, gentlemen, yet I hear you ask me: What have we as Master Mechanics to do with it? How are we responsible? I am quite aware that your responsibility only begins when the railway is finished and its rolling stock is to be operated. You are skilled in the profession; all that

you are and all that you can hope to become depends upon the well-being and good management of railways now, and their prosperity in the future. Every week, almost every day, some practical man is sought to operate a railway; this is an assurance that you are to have more to say in these matters in the future than you have had in the past, and it therefore is well that your attention should be called to them. It is well that you, who, as practical men, are to make the earnings of the railway, should know whether its debts represent its cost or double its cost. It is well that when you go on to a new road you should know whether it has to be rebuilt after a dishonest contractor. It is well, above all, that when you are invited to a position on a new road you should know whether it is a road which, by the best management, can be made to pay at all, or whether it has been projected by some interested person for his private profit, in its construction, and can not be made to pay, and you are called to waste your energy and time in attempting an impossibility. The railway having been built, and being in operation, is your particular department free from all blame for the disaster about us? The traveling public, like every other portion of the community, seek ease and luxury. These parents of effeminacy they pay for with more willingness than they do for their railroad fare. They get a pass over the road if they can and pay with pleasure for the luxurious sleepers or the parlor cars. This public demand for luxury has created a rolling stock as great in weight as it is delightful in ease. You know the cost of operating such rolling stock, you know the weight of the locomotive required to move it, you know the excellent condition of the track indispensable to operating it at a high rate of speed with safety. Have you studied carefully to know whether the road with which you are connected can afford to be operated with this luxury and at this speed? Are not lighter engines and cars and a more moderate speed essential to profit in operating many of our railroads? You reply, that all this luxury and this great speed is no fault of the mechanical department; that it exists in consequence of a public demand, and that the public alone are responsible. The public are like a spoilt child in the matter; they take all the sweet they can get, and cry for more. This calls upon you to exercise all your firmness and all your wisdom, to put an end

to a losing business, which you know must end disastrously. Let me beg every one of you, then, to renew your assiduity in these matters, and to do all you can to cause heavy rolling stock to be removed from the roads you serve, unless the traffic is so enormous and lucrative as to bear the expense it entails. Involved in this question of operating the rolling stock for which you are directly responsible, is the cost of moving large bulks great distances and selling them at a profit. I had the honor very briefly to call your attention to this point a year ago. All the injury to the railroad interest of the country, which a misconception of this great question could do, has been worked within a year. It is hardly possible to overestimate that injury. It had its origin in something akin to fraud, perpetrated by those who projected and constructed railroads on the people of neighborhoods through which they passed.

To obtain from the farmer pecuniary aid in the way of donations by representing to him that his bulky freight, in the shape of farm products, would find a high market and at a low rate of freight, was one unfailing financial resource of the projectors of these unnecessary roads. It was the hope held to the view of the honest and unsuspecting husbandman built upon a foundation of misrepresentation and falsehood. It has borne the bitter fruit which might have been foreseen. The deceived farmer finding the rate charged by the railroad did not bring him the promised market for his products became a Granger, the Granger became a legislator and treated the railroad interests of great States with arbitrary laws and enactments. To regulate trade, not by the laws of supply and demand, not by the cost of doing the business, but by legislative enactments; to say that a railroad shall haul a ton of freight for one-half a cent, when the absolute cost of hauling is one cent a ton, is as if you should require the farmer to sell his corn at twenty-five cents a bushel, when he can realize fifty cents by feeding it to hogs; or as if you should legislate him into a sale of his hogs at some particular place in the State at half their market value. This seems absurd enough; nevertheless, the Granger, deceived into donating his money to build the railroad, legislates with the passion of resentment, not with the wisdom which follows calm reflection. In Wisconsin the railroads complain that this legislation amounts to a confiscation of the railroad property.

What doubt, what distrust, what absolute ruin overhangs a great commercial interest thus threatened by hostile legislation!

Again, gentlemen, I hear you ask me: Is this our work? Did we build these roads? Did we deceive the farmer? Did we touch their donated greenbacks? Not at all; but, gentlemen, you are the practical operators of these roads. The farmer does not seek a dry goods' clerk to till his fields or to gather his harvest. Every week, almost every day, we hear that the practical railroad mechanics are coming to the management of railroads. You should know the cost of operating these roads, and you should know how to operate them at the least possible cost, and it is the duty of every one of you, as you would protect the great commerce with which you are identified, to educate both Granger and legislator as to the cost of transportation, so that they shall not do a great wrong to your traffic, any more than you would legislate them out of the true value of the products of their soil. The Granger must be reminded that before the railway was constructed he had no market for his products beyond the distance they could be hauled in wagons and profitably sold; whereas he now has a much wider and better market, although not always the highest in the whole United States. He must be reminded that so eager was he for the construction of a railway near his farm that he often solicited its building, at a high cost, rather than that it should not be built at all. Thus he became, in a great degree, responsible for its construction. He has no right now to shirk his share of the responsibility, least of all has he a right to legislate adversely to the interest he did so much to create. His best course is to protect the railway, to do all that he can to make it earn a fair interest on its true cost, for the prosperous road will be a real benefit to his property, while a bankrupt road is a burden to him as well as its owners.

Gentlemen, among the other causes of embarrassment to the rail roads, bearing directly upon it with a dead weight, is the question of the currency.

I am not about to discuss a subject on which the ablest minds differ and all men have strong opinions; not because it is not of vital importance, for if I had the ability to claim your attention on so great a theme, I feel I ought not to take your time for more than a

passing reflection. Sound political economy, average common sense, and the inexorable teachings of history concur in showing that an irredeemable paper currency is the greatest curse that war inflicts upon a nation. Its blighting influence is felt by the railway interest even more fatally than by any other. It furnishes the means to unprincipled speculators to build parallel lines and unnecessary roads. It is not too much to say that the railway business could not have been overdone, to the extent it now is, unless the means had been furnished by irredeemable paper.

Gentlemen, I turn from this digression to other considerations, which bear upon the present non-paying condition of railways. As practical men, most if not all of you competent to practically operate a railway, I ask you if it has been ascertained yet that a steel rail is a necessity. If a better iron rail were made, involving but slightly increased expense, would the steel rail be required? In this question is involved the cost of producing a first-class iron rail in this country. That cost is by no means as low as it should be. The coal and iron miners of this country, unfortunately for the welfare of the railroads, attempt to enjoy an annual strike. They attempt this carnival with such regularity that they are obliged to earn in six months enough to sustain themselves and their families a year. They would make better citizens, form better communities, earn more money at a lower rate of wages, and produce double the quantity of iron, of a better quality, if they worked all the year round. And then, I ask you, would there be any need of steel rails? If there is no need of steel rails the cost of a first-class road would be materially decreased thereby, and a lower rate per passenger and per ton of freight would suffice for the interest on that cost.

Gentlemen, while we call on the laborer in the mines to be sober, industrious, skillful, and continuous in work, we must not shrink from considering how far our own labor, and the labor which we employ, has been at a rate so high as to materially interfere with operating the railroads of the country at a proper cost. A widespread extravagance of living has prevailed throughout the country since the war. If this is one of the causes of the high price of labor, and if, through it, disaster is to succeed disaster to the railroads of the country, every hour that the day of reckoning is put off only

makes that reckoning more certainly necessary and that ruin more general. It is our duty, therefore, to look the question squarely in the face, and to take those steps which prudence and wisdom demand, that our part in meeting a question so delicate and so full of difficulty may at least be fully and fairly done.

Gentlemen, we are in the city of Chicago—out of the lurid flames of its terrific fire, from dust and ashes, it has risen, and now spreads itself out in beautiful and magnificent proportions. History furnishes no parallel to this magical creation. The world has never before furnished a people with such unbounded enterprise and faith, supported by a country of such fertility and resource. You have everywhere seen the welcome it holds out to you for every enjoyment, and from what I know of you I believe you will, with becoming modesty, not fail to avail yourselves of its pleasures; but do not forget that here are to be found some of the most modern and interesting applications of the mechanical arts to every necessity and luxury of civilization. Let these attractions claim from pleasure some of the hours which will not be required in attendance here.

Gentlemen, it may seem to you that the facts I have cited and the truths I have pointed out, give too unfavorable a view of the industry in which we are engaged. I have not sought to be unhopeful or a prophet of ill. Indeed I have every confidence in the prosperous future of the railway interests of the country, if all connected therewith do their duty; and it has seemed to me that on an occasion like the present, where the whole subject is legitimately before me, I should fail of my duty did I not point out, to the best of my ability, what seem to me the causes of the present difficulties, and suggest some means of overcoming those difficulties, leaving to you all those hopes which spring spontaneously to the mind, whenever it is suffered to dwell upon an industry which is as wide as the continent over which it is spread, and of which it may well be predicted that its growth and prosperity will go hand in hand with the prosperity and power of the countries it does so much to develop.

The critical condition of the railroad industries at the present time, the ignorance and misapprehension which exist upon all the subjects involved in moving large bulks great distances at any reasonable cost, the necessity of enlightening the public mind,

and awakening the public reason, to the truth upon these subjects, renders this an eventful era in the history of railroads.

Here, in the commercial capital of the State where the Granger was first maddened into legislating upon rates and tariffs of freight without reference to the cost of transportation, it is eminently fitting the first steps should be taken to guide his footsteps toward the paths of reason and justice. This will require patience, good temper, and forbearance, because the enactments of folly are precipitate and easy, while the revolutions of wisdom are slow and difficult.

THE PRESIDENT—The next business in order will be the reading of the report of your Secretary.

SECRETARY'S REPORT.

H. M. BRITTON, *President American Railway Master Mechanics' Association:*

DEAR SIR—I herewith hand you my official report for the year ending May 12, 1874.

Money received during the year is as follows:

By assessment	$2,150 00
By donation	55 00
Initiation fees	32 00
From Naval Bureau	1 50
Total amount of money received	$2,238 50

An excess over that of last year of $171, which has been turned over to the Treasurer and receipts taken for the same.

A detailed statement of the number of Annual Reports and Circulars sent from this office, and the expense attending the same, is herewith respectfully submitted:

Total number of Circulars distributed	1174
Postage on the same	$11 74

The number of Reports distributed are as follows:

Sixth Annual to Superintendents	150
" " " Members by mail	753
" " " Miscellaneous parties	162
" " " Master Mechanics not members	100

Total number sent	1367
Number sent by express	202
Number sent by mail	1165
Postage on same	$69 90
Postage on Miscellaneous Reports	14 00
Total Postage on Books and Circulars	$95 64
Miscellaneous Postage, Money Orders, etc	29 91
Making the total amount of Postage	$125 55

The Association has on hand the following Annual Reports:

Of the First and Second each	716	copies
Of the Third	168	"
Of the Fourth	72	"
Of the Fifth	329	"
Of the Sixth	133	"

There are also two thousand large envelopes for circulars, five hundred small size, and eight thousand four hundred engraved letter headings, with which to begin the new year.

Since my last report, thirty-two members have joined the Association. Of these twenty-six became members at our annual meeting in Baltimore, and six by authorizing the Secretary to sign their names to the Constitution, as provided for in Article IV.

During the year eight have requested that their names be taken from the list of members. Of these, one resigns on account of his name being omitted from the list of members in last year's report; one on account of not being able to pay his dues; three on account of leaving the business; one on account of not being able to attend annual meetings, and two have assigned no reason.

J. Lawrence Smith, of Louisville, an Associate Member, has resigned, and asked to have his name stricken from the list of members.

At our Sixth Annual Meeting Mr. Wells, of the Jeffersonville, Madison & Indianapolis Railroad, introduced the following amendment to Article IV of Section 4 of the Constitution, which, on motion, was unanimously adopted:

"Any member who shall be two years in arrears for annual dues

shall have his name stricken from the roll, and be duly notified of the same by the Secretary."

In accordance with this provision, your Secretary issued circular letters to all of that class, reciting the above Article, and the necessities of the Association for prompt payment of dues. This was responded to by twelve members sending their assessment. Four have promised to do so soon, and twenty-one have never been heard from. There is no doubt that many members have left the business, and their address is unknown; and others who are too modest to ask the Company, and unable of themselves, to pay their dues, take this silent method of canceling their obligations. The enforcement of this rule of our Constitution reduces our number twenty-five.

In thus referring to the history of our membership it may not be out of place to call your attention to the fact that one of our number who has been an active member of our Association since 1869, is also one whose name will be stricken from our rolls. I refer to J. B. Gayle, who died at Raleigh, N. C., April 7th. Another, J. B. Pendleton, although not a member at the time of his death, withdrew only because he felt the Association was not properly appreciated, and there was no encouragement to remain. This feeling was no doubt caused, in a great measure, by the disease that ended his life, for he, too, is dead, and his name deserves honorable mention among members of our profession.

This leaves our number with an increase of twenty-one, as compared with last year, making the total membership 243.

Very respectfully submitted,

J. H. SETCHEL.

THE PRESIDENT—You have heard the report of your Secretary. What action will you take upon it?

On motion, it was received.

THE PRESIDENT—The next business in order will be the report of your Treasurer.

TREASURER'S REPORT.

S. J. HAYES, Treasurer, in Account with

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.

DATE.	MAY 12, 1873, TO MAY 11, 1874.	DR.	DATE.	JUNE 29, 1873, TO MAY 12, 1874.	CR.
1873.			1873.		
May 12......	To Balance forward	$122 74	June 29......	By Salary of Secre'ry, Voucher 1,	$500 00
June 29......	" Cash from Secretary............	500 00	June 29......	" Short hand Reporter.... " 2,	125 00
June 29......	" " " "	725 00	June 29......	" Rent of Hall................ " 3,	100 00
Sept. 29......	" " " "	50 00	Sept. 29......	" Analyzing Water......... " 4,	50 00
Oct. 18	" " " "	81 00	Nov. 4......	" Receipts and Envelopes " 5,	20 15
Nov. 4.....	" " " "	80 15	Nov. 19......	" Printing Annual Report " 6,	871 16
Nov. 19.....	" " " "	130 00	1874.		
Nov. 28......	" " " "	50 00	Jan'y 21......	" Reports 1st and 2d Year " 7,	265 00
1874.			Jan'y 21......	" Telegraphing and Po.... " 8,	3 00
Jan'y 13	" " " "	90 00	Jan'y 13......	" Postage, etc................ " 9,	92 55
Jan'y 13......	" " " "	92 55	May 12......	" Postage .... " 10,	36 00
Mar. 30......	" " " "	140 00		" Balance on hand..................	298 38
May 11......	" " " "	299 80			
		$2,361 24			$2,361 24

Respectfully submitted, S. J. HAYES, TREASURER.

On motion, the report was received.

THE PRESIDENT—The next business will be the report of the Finance Committee.

FINANCE COMMITTEE'S REPORT.

To the American Railway Master Mechanics' Association:

GENTLEMEN: The undersigned, a Committee appointed to examine the accounts have attended to that duty, and find the reports of the Secretary and Treasurer for 1873 correct, and recommend an assessment of ten dollars to defray the expenses of the current year.

Respectfully,

EDWIN GARFIELD,
CHARLES GRAHAM, } *Committee.*
GEO. RICHARDS,

On motion, the report was received.

MR. HAYES (Illinois Central)—Mr. President, as there will be considerable correspondence coming before the Convention that will take up much time, I would, therefore, offer the following resolution, in order to facilitate business:

"*Resolved*, That all local correspondence intended for this Convention shall be referred to the General Supervisory Committee for their consideration and action.

The resolution being seconded by Mr. John Thompson, of the Eastern Railroad, was adopted.

THE PRESIDENT—All those who have any correspondence to present to this Convention will please leave it on the desk of the Chairman.

MR. ROBINSON (Great Western Railroad)—I move that the President appoint a committee in accordance with the report of the Finance Committee, for the collection of dues, so that that business may be attended to as early as possible.

MR. HAYES (Illinois Central Railroad)—I second the motion.

Carried.

THE PRESIDENT—For that Committee the Chair will appoint the present Finance Committee, consisting of Messrs. GARFIELD, H. P. & F. R. R.; GRAHAM, L. & B. R. R., and RICHARDS, B. & P. R. R.

Mr. GARFIELD—I shall be unable to do anything this forenoon. I am quite unwell, and any exertion aggravates the difficulty.

THE PRESIDENT—The next business in order will be the report of the Committee on the Operation and Management of Locomotive Boilers, including the Purification of Water, which is in the hands of your Secretary.

Report of Committee on the Operation and Management of Locomotive Boilers, Including the Purification of Water.

To the American Railway Master Mechanics' Association:

GENTLEMEN: Your Committee, appointed at the last Annual Convention to continue their investigation of the above subject, beg to report that they issued the following circular of inquiry for such information as the experience of the members might suggest.

CIRCULAR.

By reference to the reports and discussions, you will not fail to notice that each year marks an advancement towards a solution of the subject of Boiler Incrustation, and while the Committee feel greatly encouraged, they likewise realize the necessity of still further investigation. It is hoped, therefore, that each member will take the following questions under careful consideration, and by contributing one or more facts, assist in arriving at a satisfactory conclusion.

1st. Is it in your opinion practicable to purify water for locomotive boilers at watering stations on the line of your road? If so, by what means?

2d. Do you consider it practicable to store rain water in reservoirs? If so, what form of reservoir would you recommend, and what, in your opinion, would be the expense of a permanent fixture of this kind?

3d. Would not the use of rain water entirely overcome the evil of incrustation?

4th. Do you believe any mechanical or chemical means can be practicably and economically employed, by heat or otherwise, to effectually purify water for locomotive use?

5th. Has your experience in the use of boiler compounds demonstrated that such nostrums can become a practicable, cheap, and effectual remedy for the evil in question?

6th. Has your experience with the mud drum, since the meeting of the last Convention, developed any new facts in its favor?

7th. What means have you adopted for removing scale or incrustation, and what would you recommend?

8th. What method of staying crown sheets, other than the ordinary way, would you advise as a means of preventing the accumulation of mud and scale?

The Committee will be pleased to receive samples of incrustation, for analysis (and for the benefit of the Mechanical Laboratory), which please label with name of road, and mileage of engine in which they accumulated. Also, please send, if possible, an analysis of the water used in engines on your road, name of place from which it was taken, and its effect upon your boilers.

MANAGEMENT OF STEAM BOILERS.

1st. What, in your opinion, should be the maximum or working pressure of boilers, as built by locomotive builders of this country?

2d. As a means of greater safety, should not every steam boiler be provided with a water gauge, in addition to the usual gauge cocks?

3d. Do you consider low water detectors, as at present manufactured, reliable, and would you recommend their application to all steam boilers? If you have ever used them, please state your experience.

4th. What has been your experience with super-heaters; are they desirable, and can they be so attached to locomotives as to become efficient, practicable, and cheap?

5th. Do you know of any lagging for locomotive boilers and cylinders better than wood, to prevent the radiation of heat?

6th. What is your opinion of asbestos, or any other felting, as a covering for steam pipes, stationary boilers, etc.

H. A. TOWNE, *Northern Pacific*,
A. H. DeCLERCQ, *International & Gt. North'n*,
H. ELLIOTT, *Ohio & Mississippi*,
COLEMAN SELLERS, *Philadelphia*,
T. W. PEEPLES, *Central of New York*,
} *Committee.*

Please address your reply to H. A. Towne, St. Paul, Minn.

The Committee has received but few replies, and while they feel thankful for small favors, they had nevertheless hoped for an expression of some kind from most of the members, yet when it is considered that this subject has appeared before them so many times, and that many of them have replied to previous circulars, it is not surprising that the matter has become a little stale; but as each year's experience ought to develop something new, the Committee had reason to hope for some new discoveries in this direction.

In the absence of anything essentially new, the Committee will confine itself to a review of some of the leading features of former reports, with additional hints touching upon the various phases of this question, by eminent authors.

First. Incrustation, its causes, effects, and cures.

Second. The deposit of sediment, its effects and remedy.

Third. The impurities in water which produce priming, its effects, and only remedy.

It may not be necessary to dwell upon the formation of incrustation in boilers, its causes are already so well understood, that it needs no special comments; suffice to say, that carbonates and sulphates of lime, and carbonate magnesia are the prevailing elements contained in the waters which form incrustation. Chloride of sodium, fire clay, alumina, and silicates are also often found, but generally in diminished quantities, so that probably a large proportion of the difficulty would be overcome by expelling the lime and magnesia. This can be done by evaporation, or by chemical means, but such a process would be too expensive, as has been clearly shown in former reports. In reference to the first feature in the classification, the Committee can not do themselves more credit than to quote from Dr. Joseph G. Rogers, on Steam Boiler Waters and Incrustation, as read before the American Association for the Advancement of Science, 1871.

THE DOCTOR'S PAPER.

All waters used in steam boilers contain, in solution or suspension, more or less mineral matter, acquired by contact with the earth's surface, or by percolation through its alluvium and rocks. Of this, sea water contains about 2,500 grains in the gallon, in solution ;

river and lake waters, from 5 to 20 grains, in solution, and a varying quantity in suspension, generally exceeding 10 grains. Well and spring waters hold but little in suspension, but in solution, a quantity varying from 10 to 650 grains. This mineral matter consists of a variety of substances: the carbonates of lime, magnesia, and iron; chlorides of calcium, magnesium, and potassium; sulphates of lime, magnesia, soda, and potash; phosphate of lime; bromides and iodides of calcium and magnesium; alumina and silica. Besides these mineral substances, more or less vegetable matter is found, which is derived from the same source. Certain gases are more or less present: these are oxygen, hydrogen, carbonic acid, and sulphureted hydrogen—the three first being always found. Very rarely, salts of nitric and nitrous acids are found in the waters of wells in certain localities. All of the above substances are not uniformly present; the quantity and character of the mineral matter in any particular water depends much on the constitution of the earth and rocks over or through which it has passed, and upon the conditions of location, and motion, and exposure to light, heat, and air, which it has undergone; conesquently, there is much variety in the constitution of various waters with reference to their adventitious ingredients.

Upon this variety depends the variation in their adaptability for use in steam boilers. All water, on being evaporated by boiling in an open pan, leaves a residue, composed of all the mineral elements contained in it. The deposit of this residue takes place in the following manner: As soon as ebullition begins, the contained free gases are driven off, since they are not soluble in hot water, and, as the presence of carbonic acid is necessary to the solution of the carbonates of lime, magnesia, and iron, these salts which are found in all waters, are precipitated in a finely crystalline form, tenaciously adherent to whatever they fall upon. Sulphate of lime, which is commonly present, is soluble in 400 parts of cold water, but scarcely at all in boiling water; therefore, as the evaporation proceeds, supersaturation occurs, and this salt is thrown down in the same form and possessing the same adherence as the carbonates. The other contained elements, which are more soluble, are precipitated in the same way, by supersaturation. As the quantity of water is lessened

the suspended matter gradually subsides, and agglutinates with the other deposits. In a steam boiler, the deposit from the evaporated water tends to take place in the same manner, but the constant supply of fresh portions, and the occasional emptying out of the saturated water, prevents the precipitation of the more soluble salts; these are retained in solution. Practically, it is found that the deposits from all kinds of boiler waters consist almost entirely of carbonates of lime, magnesia, and iron, and the sulphate of lime. Scarcely more than five per cent. of other salts are found. In marine boilers, a mushy rèsiduum of chloride of sodium is precipitated, but incorporates itself only to a slight extent with the agglutinated incrustation of the above-mentioned salts. This latter deposit gradually accumulates, unaffected by the force of the boiling currents, becoming thicker and harder, until, if not removed, it becomes as dense as porcelain and much tougher. Under the influence of high heats, this scale is often converted into absolute glass, by the combination of the silica, deposited from suspension, with the bases of the carbonates.

EFFECTS.

The evil effects of scale are due to the fact that it is relatively a non-conductor of heat. Its conducting power, compared with that of iron (according to Despretz) is as 1 to 37.5—about; accordingly, more fuel is required to heat water through the shell and flues of an incrusted boiler than would be required if the boiler were clear of scale. It is readily demonstrated that a scale one-sixteenth of an inch thick will demand the extra expenditure of about 15 per cent. more fuel. This ratio increases as the scale grows thicker: thus, when it is one-quarter of an inch thick, 60 per cent. more fuel is needed; when it is one-half inch thick, 120 per cent., and so on. The crust sometimes becomes so thick as to prevent a sufficient heating of the water by the burning of any amount of fuel that can be placed in the furnace. If a boiler be perfectly clean, the contained water may be raised to any given temperature by heating the external fire surface to a temperature a few degrees higher; but if any scale be present it will be necessary to heat it still higher, according to the thickness of the scale, in increasing ratio. To illustrate: To

raise steam to a pressure of 90 pounds, the water must be heated to 320 degrees Fahrenheit. If the boiler be clean, this may be done by heating the fire surface to about 325 degrees; but if one-half inch of scale intervene between the shell and the water, such is its non-conduction that it will be necessary to raise the fire surface to a temperature of about 700 degrees—almost low red heat. Now, the higher the temperature at which iron is kept, the more rapidly it oxydizes or carbonizes and undergoes molecular change. At any temperature above 600 degrees it soon loses the fibrous nature of the wrought iron, and becomes granular, like cast-iron (which it has really become), by carbonization. In this condition it is brittle, thin, and, under high heats, liable to bulge, or even give way to the great pressure upon it. Weakness of boilers thus produced predisposes them to explosions, and causes necessarily expensive repairs. Another evil resulting from the presence of scale is that it renders slower and more difficult the raising, maintaining, and lowering of steam.

PREVENTION.

To obviate these evils—namely: Danger from explosion, expense of repairs, loss of time, and waste of fuel—very many methods have been devised having in view the prevention and removal of scale. For this purpose, picking, scraping, chaining, etc., are generally resorted to periodically. Such is its toughness and tenacity, however, that mechanical force only succeeds in removing a portion of it, and is generally unsatisfactory, since, in addition, it is necessary, to empty the boiler and allow it to get cool enough to enter, which, with the operation itself, generally requires a whole working day.

Various mechanical contrivances have been, and are now, used to intercept the precipitated saline matter from the supply water on its passage through the heating apparatus. They consist, essentially, of a series of obstructions to the flow of water. This latter, being heated to boiling, by being intermingled with the exhaust steam in the heater, the carbonic acid is driven off, and a precipitation of the carbonates takes place, the deposit accumulating on the shelves, straw, or other obstructions over which the water slowly flows. In

this way large accumulations of the matter in suspension, and of the precipitated carbonates, are prevented from going into the boiler, and, being retained in the heater, may be removed very conveniently when opportunity is afforded. This plan, however, only partially remedies the difficulty, since it is only the precipitated carbonates and the matter in suspension that is retained by this apparatus. The soluble salts all pass on to the boiler, and also a great portion or the earthy carbonates, which can not be precipitated during the short passage through the heater. The scale in the boiler more slowly, but as surely, forms.

Another variety of mechanical device for preventing scale is the sediment pan. This, of which there are many forms, consists, essentially, of a shallow vessel, which is placed in the bottom of the boiler, with the view of catching the precipitate, and preventing its deposition on the inner surface of the shell. They are removed at intervals and cleaned. This plan succeeds in gathering much of the sediment, but much necessarily fastens itself to the boiler, and the scale, as before, continues to form.

It is impossible to make any mechanical contrivances completely efficacious; the great *desideratum*—perfect prevention—can not be attained by any mechanical means. To chemistry alone can we look for a complete method. For a long time, simple chemical agents have been used, in an empirical way, with a certain success Some of these, and their *modus operandi*, I will notice: Molasses, fruits, slops, vinegar, cane-juice, and a variety of vegetable substances, containing more or less acetic acid, when placed in the boiler, at regular intervals, will remove and prevent the incrustation to a certain extent. The acetic acid decomposes the carbonates, forming acetates, which are kept in solution, and hence can not become increments of scale. The sulphate of lime and other salts are not affected by it, and from this the scale will gradually be formed. Moreover, the iron of the boiler, being open to the attack of free acid, will be gradually corroded, and after a time rendered useless, if not dangerous.

This fact alone ought to forbid the use of these agents. Starchy matter—in the various shapes of potatoes, corn, oil-cake, etc.—has been much used. These prevent scale only by enveloping the pre-

cipitates with gelatinous matter, which lessens their weight and prevents their agglutination into a solid mass. Starch, as well as nearly all other organic matter, has a tendency to produce frothing of the water in the boiler; in which case the exact quantity present can not be determined by the gauge cocks. This is a source of great danger, and ought to prevent the use of such agents. Oak, hemlock, and other barks and woods are operative in the prevention of incrustation, on account of the tannic acid which they contain. Various extracts—such as catechu, logwood, etc.—rich in tannin, are also used. Tannic acid decomposes the carbonates, forming tannates, which are insoluble; but their specific gravity being light, they do not subside, but remain continually floating in the boiling currents; and, moreover, being amorphous, they have no tendency whatever to agglutination, and therefore do not incrustate on those surfaces with which they come in contact. The sulphate of lime, however, is not decomposed by tannin, and will form a scale, notwithstanding its presence. The same objection holds against tannin, in its free state, as offered in the above-named agents, as does against free acetic acid; it will attack the iron of the boiler; though, as the tannate of iron is insoluble, the corrosion will not be as rapid as with the acetic acid, which forms a soluble acetate with iron.

The fixed alkalies are much used in the various forms of lye, ashes, sal-soda, caustic soda, potash, etc. These agents decompose the sulphate of lime, the resulting sulphate of soda or potash being retained in solution, and the carbonate of lime precipitated, but in large crystals, not apt to condense into hard scale. The carbonates of lime and magnesia held in solution by free carbonic acid are precipitated by the appropriation of the acid to form carbonates or bicarbonates of soda or potash; but, as with the sulphate of lime, the crystals being larger, do not form so refractory a scale as when precipitated by boiling alone; still, as these earthy carbonates form the major part of nearly all incrustations, this method, which fails to do more than merely modify their form and qualities, without affording means for their voidance, deserves little attention. Ammonia and its carbonate have a precisely similar action, and are similarly objectionable. The alkalies have no corrosive action on the boiler, but, on the other hand, rather tend to prevent it, by appropriating

the free carbonic acid, which ordinarily combines with the insoluble crust of oxide of iron (iron rust) on the inner surface, forming a soluble carbonate, which, being constantly dissolved away from the iron, leaves a surface continually exposed to fresh action.

Muriate of ammonia is another means of obviation: This has its action only on the earthy carbonates. The resulting carbonate of ammonia, being volatile, passes off with the steam, and the chlorides of calcium and magnesium are retained in solution. This is a very efficient way of removing old scale, since the earthy carbonates constitute the greater portion of most incrustations. Its only objection is the ammoniacal odor in the steam.

Petroleum has been used with some reported success. The *rationale* of its action is difficult to give, owing to its chemical complexity.

The foregoing are methods in which a single agent is depended upon. Many compounds have been devised with a view of overcoming all difficulties; many such have been patented, and many more are sold as secret, proprietary preparations. Tannin is the basis of most of them, generally in combination with various alkaline salts and some starch-bearing substance. These elements, some useful and some useless, I have found nearly always in a state of mere mechanical mixture, and not uniform in chemical constitution. They generally contain more or less free tannic acid, which is objectionable on account of the slow corrosive effect on the boiler and an amount of insoluble, inert vegetable matter, which is liable to cause foaming. Besides these methods, in which chemical agents are put directly into the boiler, others have been devised in which the waters are depurated in tanks before entrance into the boiler. Clark's method consists of the admixture of lime, simply. This precipitates the earthy carbonates by appropriation of the free carbonic acid which holds them in solution. The newly-formed carbonate of lime, being insoluble without the presence of free acid, also falls; the supernatant water is drawn off for use; sulphate of lime and other salts remain untouched. This, in turn, might be removed by carbonate of soda—carbonate of lime being precipitated, and sulphate of soda being retained in solution. Another method, proposed by myself, consists essentially of the conversion of the

earthy carbonates into soluble chlorides by hydro-chloric acid, the excess being neutralized by filtration through carbonate of baryta (witherite) in coarse powder. The soluble chloride of barium, thus formed, will decompose the sulphate of lime, the resulting chloride of calcium being very soluble and the sulphate of baryta insoluble and very heavy; the latter subsides, forming a deposit not easily disturbed. By this method the carbonates of lime and magnesia, and the sulphate of lime, which constitute 95 per cent. of the scale-forming matter, are completely changed into very soluble chlorides, which will not form a scale under any circumstances. This plan recommends itself for railway water stations by its cheapness and simplicity. Tannic or acetic acid, the excess being properly neutralized by carbonate of soda, may be also used for tank depuration. With the tannin, insoluble tannates are precipitated; with the acetic acid the carbonates are converted into soluble acetates; the neutralizing alkali will decompose the sulphate of lime, producing soluble sulphate of soda and precipitating carbonate of lime. The carbonate of soda or potash alone may be used, as it will precipitate all the lime and magnesia as carbonates. All these tank methods require supervision, and can not, to any great extent, influence scale already formed; and, as the removal of this is as needful as its prevention, it is palpable that, for general application, that method is best which attains the complete removal as well as prevention of scale, by chemical means, operating inside the boiler. As fulfilling this indication with ease and economy, and without damage to boiler, foaming, or any other untoward result, the writer has devised the following process, which three years of extensive and varied practical trial have thoroughly tested: Tannate of soda is the agent used. This is periodically introduced into the boiler or heater, by any convenient means, in sufficient quantity to maintain a constant excess, determined by the presence of its peculiar color in the water at the gauge-cocks. It is soluble, and being constantly present, as the supply water pours in, loaded with the scale-forming salts, the following reactions are constantly going on between the tannate of soda and the carbonates of lime and magnesia. A mutual exchange of acids and basis occurs; the lime and magnesia are precipitated as tannates in a light, flocculent, amorphous form, so

that they do not subside at all, but are kept circulating in the boiling currents until they find their way into the mud receiver, there finally subsiding into a loose, mushy sediment, which may be blown out very readily from time to time as it accumulates. The carbonate of soda, formed in the reaction, is retained in solution, becoming a bi-carbonate by appropriation of the free carbonic acid of the water. This decomposes the sulphate of lime; the resulting sulphate of soda is retained in solution, and the carbonate of lime is acted upon, at the moment of precipitation, by fresh portions of the tannate of soda. The constant presence of the alkali protects the iron of the boiler from all action of tannic or carbonic acid. Since both have a greater affinity for soda than for iron, the alkali will keep both acids neutralized as far as the metal of the boiler is concerned. The lime and magnesia, however, having a greater affinity for the tannic acid than the soda has, its acid action will be operative on these bases, producing the results before detailed. The same reactions take place between the tannate of soda and the already formed scale; its exposed surfaces are gradnally disintegrated, the resulting sediment finding its way into the mud receiver.

This superficial abrasion loosens portions of the scale, which can be removed at intervals of one to four weeks, according to circumstances, until the boiler is clean; after which it will be necessary to open the boiler only at long intervals for inspection, as the tannate of soda will keep it clean, if properly used in sufficient quantities.

As the earthy carbonates and the sulphate of lime constitute the great mass of the mineral matter found in most boiler waters, and as the remaining constituents are soluble, and hence do not incrustate if the boiler is occasionally emptied, it will be seen from the foregoing that in this salt (the tannate of soda) we have an agent which perfectly fills the demand theoretically, and, as before stated, extensive trial in all kinds of waters has proven its practical efficacy. It is applicable to marine boilers, as well as those using fresh water, for the marine incrustation is almost precisely similar to that formed from the waters of rivers, lakes, etc., consisting, as it does, principally of earthy carbonates and sulphate of lime. The chloride of sodium of sea water forms a mushy deposit, if supersaturation is allowed to take place, but it is incorporated in the scale only to a

slight extent, and this is prevented, by more or less constant change of water, by blowing out both from the surface valve and from the sediment receiver.

The length which this paper has reached forbids my noticing several other methods of scale prevention, which have been proposed by myself and others. Before leaving the subject, however, I will mention a simple method for determining the hardness of waters and their fitness for boiler use.

DETERMINATION OF HARDNESS OF WATER.

A saturated, filtered tincture of soap is prepared of proof spirit and the soft soap of the pharmacopœia; also a solution of bi-carbonate of lime, by passing carbonic acid gas through lime water till it becomes clear. An ounce of this is carefully evaporated and the residue weighed. To another ounce of this solution the tincture of soap is added, one minim at a time, with shaking after each addition, until a permanent lather is formed. The weight of the above residue in grains is to be compared with the number of minims required to produce a lather. This comparison will show how many grains of hardness will be neutralized by a given number of minims of the soap tincture. This tincture, thus roughly titrated, is to be added, one minim at a time, with constant shaking, to an ounce of any water to be examined, until a permanent lather is produced; the number of minims required will indicate, by reference to the last operation, the number of grains of hardness. Tincture of soap does not alter by keeping closely stopped, and by this simple agent, with no other apparatus than a minim glass and a vial, the hardness of any water may be determined with sufficient accuracy to decide upon its fitness for boiler use.

MADISON, IND., August, 1871.

If the doctor's process, as recommended for railway watering stations, will precipitate lime, magnesia, etc., in cold water at a moderate expense, it is certainly a valuable discovery, and should at least have sufficient credence to insure a practical trial under the eye of experts.

In order to qualify Dr. Rogers' theory in a practical point of view

concerning the use of chemical compounds operating inside the boiler, the second feature in the classification may be considered. As has been stated in former reports, locomotive boilers are not constructed to admit of the ready removal of incrustation, nor can they be, and prove efficient for all they are designed to do, including the ready removal of sedimentary deposit. Chemical compounds for the removal of incrustation, operating inside the boiler, is an old remedy, and it may be conceded that some of them will remove and prevent the formation of scale, probably without serious injury to the iron, but their introduction into the boiler adds still more to the impurities already in suspension, which, in combination with the dislodged scale, falls, if unobstructed, gradually to the bottom, in a semi-fluid mass, and if not removed when in this state it will become so hardened as to render it impossible to remove it by any ordinary means of blowing off or washing.

It is a question, then, whether the "flocculent amorphous" form which Dr. Rogers says the sediment assumes in the boiler by the chemical action, and which floats in the current of ebullition till it reaches the mud receiver, where it may be readily blown out, from time to time, does not lodge in its descent upon the tubes and internal surface of the boiler, while the water is at rest, and then become hard by the action of the heat remaining in the boiler.

If the water is let out of the boiler, or blown out under pressure, as is frequently the case, the hardening of any sedimentary substance is inevitable. The floating substance must necessarily settle as the water recedes, and how it can pass down through a boiler full of tubes not more than $1\frac{1}{16}$ of an inch apart, without lodging upon them, just in proportion to the consistency of the rile, is not easily understood. Besides, whatever amount of sediment reaches the bottom of the boiler is equally distributed throughout the entire length and breadth of the same, and the blow-off cock in the mud receiver will only remove that contained in the receiver, and as much in the boiler as the force of the eddy may reach by the action of the current passing through the cock.

DEPOSIT OF SEDIMENT.

Regarding the injurious effects of the deposit of sediment, we

we will refer to the reports of inspections made by the Hartford (Conn.) Steam Boiler Inspection and Insurance Company, for the months of March, October, and November, 1873. The whole number of boilers inspected during the three months was 7,173; of this number 2,161 were inspected internally and entire, and 3,290 were found defective. Cases of incrustation and scale, 587—50 dangerous. When boilers are not blown down frequently, impurities in the water become concentrated and act very injuriously on the iron. Deposits of sediment, 570—82 dangerous, 20 of which were very bad, with great danger of burning the fire sheets, so they would become contorted and dangerously fractured. Whole number of burned plates (which may be attributed to the deposit of sediment), 207—87 dangerous. Whole number of defective boilers from incrustation, deposit of sediment, and burned plates, 1,364—219 dangerous.

It will be seen that nearly half of the whole number of defective boilers became so on account of incrustation and deposit of sediment, and, strange as it may seem, there was 40 per cent. more dangerous cases from the deposit of sediment than from incrustation and scale. This evil in locomotive boilers is as difficult to overcome as that of incrustation itself.

Thence again comes the objection to the use of boiler compounds, and the necessity of purifying the water and allowing it to settle before taking it into the boiler. It is not unfrequent that the space between the flues in locomotive boilers is found full of sediment and literally joined together in one solid mass half way up the boiler, and packed so hard as to render it impossible to wash it out after several of the flues have been removed.

A similar case came under the notice of Mr. Towne, of the Northern Pacific Railway. After the flues were removed from engine 117, there remained nearly one-third of the boiler full of this deposit, and some of it so hard as to make it necessary to use a pick for removing it.

(The above statistics further illustrate that more than half the defective boilers from other causes are due to careless and incompetent management, proving clearly that a large number of cases from which explosions might be expected may be traced to a direct cause.)

THE PURIFICATION OF WATER BY DR. CLARK.

His process for purifying water for the use of cities has proved a success, and it is said to be as cheap and efficient for railway purposes as for domestic use. Your Committee beg the indulgence of the Convention in the reading of his excellent and able delineation of this subject. He says in order to explain how the invention operates, it will be necessary to glance at the chemical composition and some of the chemical properties of chalk; for which chalk makes up the great bulk of the matter to be separated. Chalk also contains the ingredient that brings about the separation. The invention is a chemical one for expelling chalk by chalk.

Chalk then consists, for every one pound of 16 ounces, of lime 9 ounces, carbonic acid 7 ounces. The 9 ounces of lime may be obtained apart by burning the chalk, as in a lime-kiln.

The 9 ounces of burnt lime may be dissolved in any quantity of water, not less than 40 gallons. The solution would be called lime water. During the burning of the chalk to convert it into lime, the 7 ounces of carbonic acid are driven off. This acid, when uncombined, is naturally volatile and mild; it is the same substance that forms what has been called soda water, when dissolved in water under pressure. Now, so very sparingly soluble in water is chalk, by itself, that probably upward of 5,000 gallons would be necessary to dissolve one pound of 16 ounces, but by combining one pound of chalk in water, with 7 ounces additional of carbonic acid, that is to say, with as much more carbonic acid as the chalk itself contains, the chalk becomes readily soluble in water, and when so dissolved is called bi-carbonate of lime. If the quantity of water containing the one pound of chalk, with 7 ounces additional carbonic acid were 400 gallons, the solution would be a water of the same hardness as well water from the chalk strata, and not sensibly different in other respects. Thus it appears that one pound of chalk, scarcely soluble at all in water, may be rendered soluble in it by either of the two distinct chemical changes. Soluble by being deprived entirely of its carbonic acid, when it forms lime water, and soluble by combining with a second dose of carbonic acid, making bi-carbonate of lime.

Now, if a solution of the 9 ounces of burnt lime forming lime

water, and another solution of the one pound of chalk, and the 7 ounces of carbonic acid forming bi-carbonate of lime be mixed together, they will so act upon each other as to restore the two pounds of chalk which will leave, after the mixture subsides, a bright water above.

The water will be free from carbonate of lime, burnt lime, and chalk, excepting a very little, which we keep out of account at present, for the sake of simplicity in this explanation. The following table will show what occurs when this mutual action takes place:

Agents.		
Bi-carbonate of lime in 400 gallons.	Chalk with carbonic acid 7 ounces.	16 ounces—16 ounces of chalk.
Burnt lime in 40 gallons of lime water,	9 ounces.	

A small residue of the chalk always remains, not separated by the process; of 17½ grains, for instance, in a gallon of water, only 16 grains would be deposited, and 1½ grains would remain. In other words, water with 17½ ounces of hardness, arising from chalk, can be reduced to 1½ ounces, but not lower.

These explanations will make it easier to comprehend the successive parts of the softening process.

Supposing it was a moderate quantity of well water from the chalk strata around the metropolis that we had to soften, say 400 gallons. This quantity, as has already been explained, would contain one pound of chalk, and would fill a vessel 4 feet square by 4 feet deep. We would take 9 ounces of burnt lime made from soft upper chalk; we first slack it into a hydrate, by adding a little water. When this is done we would put the slacked lime into the vessel where we intend to soften, then gradually add some of the water in order to form lime water. For this purpose at least 40 gallons are necessary, but we may add water gradually till we have added twice as much as this; afterward we may add the water more freely, taking care to mix intimately the water and the lime water or lime; or we might previously form saturated lime water, which is very easy, and then make use of this lime water instead of lime, putting in the lime water first and adding the water to be softened.

The proportion in this case would be one bulk of lime water to

ten bulks of hard water. It is of importance that the lime water, that is the softening ingredient, be put into the vessel first, and the hard water gradually added, because there is thus an excess of lime present up to the very close of the process. Instead of lime water, the lime itself may be put at once into the vessel, and some of the water to be softened added gradually to dissolve it. The soft water thus obtained has no action on lead pipes or cisterns, as many soft waters have. One ton of burned lime used for softening, will produce three and a half tons of precipitate. The present water supply of the metropolis, if subjected to this process, would deposit about fifty tons of chalk daily. The process was in operation on a large scale for several years (1854 to 1861) at Plumstead, near Woolwich, where 600,000 gallons daily were operated upon with most satisfactory results. These works are now given up, although for reasons quite apart from any failure in the process.

Several water works have since been erected, or are in course of erection, by Mr. Homersham, C. E. London, for supplying water from the chalk springs softened by Clark's method; for example, at Castle Howard, seat of the Earl of Carlyle (1858), at Catherham, Surrey, for the supply of Catherham, Warlingham, and several neighboring towns (1861), at Shooter's Hill, Kent, for the War Office, for softening the water for the Kent Company, for the supply of the Berbent Hospital, etc., (1865), at all of which works the process is in successful operation. Mr. Homersham has also nearly completed works near Terry, Herts, for the supply of Triery Aglesburg, and other towns, with softened spring water.

Mr. Homersham finds that spring water from chalk can readily, on the large scale, be softened down from 4½ to 2½ degrees of hardness. This (Clark's) process is not confined in its effects to softening; it has a decided influence as regards organic impurities, for it not only removes the active source of corruption, which exists in all chalk water, as above explained, but the precipitated chalk carries down with it a large proportion of such organic matters as may be already present.

Several calico printers in Lancashire have had this process in use for several years, for the improvement of the quality of the water employed in their business.

We are not aware that this process has been tried for railway purposes, but like that of Dr. Rogers, it recommends itself, and your Committee would advise a practical trial of each process, and, if found cheap and efficacious, it could be advantageously employed to purify, or at least improve, the quality of water at watering stations, where rain and surface water can not be cheaply provided.

PRIMING.

Impurities in water which produce constant priming, is confined, in this country, almost exclusively to the alkali regions, and is composed essentially of potash and soda; ammonia and lithia are sometimes found in distinction from the fixed alkalies. The peculiarities of this water are such that it can not be practically purified for locomotive use. Surface water should, therefore, be avoided in sections where alkali exists, and deep wells sunk near streams, or rain water stored in reservoirs must be depended upon. Priming seldom takes place using water containing strictly calcareous substances. Locomotive boilers using surface water are apt to prime if allowed to become dirty, owing to the alkaloid condition of the decayed vegetable matter held in suspension, thus adding to the sedimentary accumulations already referred to, by taking such water into the boiler, without first freeing it from these troublesome collections by filtering or settling.

CHEMICAL COMPOUNDS.

Concerning the use of chemical compounds, the Committee is disposed to give them all the credit that a thorough investigation of their merits will warrant, and with a view to making reference to some of them which might be found (by submitting them to chemical test) uninjurious to iron, we addressed all the leading compound manufacturers in the name of the Committee, asking for an analysis of their preparation, or an affidavit from competent chemists, stating its effects upon iron under the treatment to which it would be subjected to in steam boilers.

Some signified their willingness to furnish an analysis, while others objected, on the grounds that by revealing the secret their busi-

ness would thereby be destroyed. They would guarantee their preparation, and make no charge if it failed to prove as recommended, etc.

Such excuses are hardly admissible, since the Committee, in their inquisition, assume the honor of the physician who never disgraces his profession by exposing his patient.

Mr. Lord, of Philadelphia, has furnished the Committee the following evidence concerning the merits of his preparation:

Mr. George W. Lord, Philadelphia:

DEAR SIR—We have made a chemical examination of your boiler compound, used for the prevention and removal of boiler scales, and find that it is free from any substances that could prove injurious to the iron boiler.

[Signed.] Respectfully yours,

BOOTH & GARRETT, *Chemists,*

Nos. 919 *and* 921 *Chant st., near St. Stephen Church, Philadelphia.*

MARCH 5, 1874.

Sworn and subscribed before me this 11th day of March, 1874, Chas. Gugger, Ald.

JAMES C. BOOTH,
THOMAS H. GARRETT.

We have the following certificate from Mr. Lighthall:

CHICAGO, September 20, 1872.

This is to certify that I have submitted to chemical examination the commercial article known as Lighthall's Anti-Incrustator, for removing and preventing incrustation in steam boilers, manufactured by J. N. Lighthall & Bro., of Chicago, and can confidently assert as the result of such examination, that no one of the ingredients used in its preparation, either alone or as here combined, is capable of corroding iron, or can be injurious to steam boilers at any temperature.

[Signed.] JAS. V. Z. BLANEY,
Analytical Consulting Chemist.

Jas. V. Z. Blaney, being duly sworn, says that he has read the above certificate by him subscribed, and that the same is true to the best of his knowledge and belief.

Subscribed and sworn to before me this the 20th day of March, A. D. 1874.

WALTER BUTLER, N. P.

We beg to present for your consideration certificates concerning one more article of this kind, known as Steatite Talc, consisting simply of prepared soap stone.

It is a foreign discovery but recently patented in the United States, and promises to supersede all other preparations for this purpose, owing to its exceeding cheapness, simplicity, and most desirable effects. An extended investigation of its merits will be made in this country during the present year, and the result reported to the next Convention.

This Steatite Talc is an essential mineral matter which has been submitted to a most careful chemical analysis, and was found to contain the following substances, viz.:

Silica	0.595	parts.
Magnesia	0.310	"
Protoxide of Iron	0.040	"
Water	0.030	"
Alumiue	0.015	"
Magnetic Iron	0.005	"
And other substances	0.005	"
	1.000	"

Mr. TOWNE, Hannibal & St. Joseph Railroad—Mr. President, allow me to make a remark in explanation of Steatite Talc. Perhaps, in the reading of the report, the members may not have understood what the article is. It is simply pulverized soap stone. That has been used in the old country for quite a long time, and is spoken of very highly by these parties. Its effect upon boilers is to remove as well as to prevent incrustation, and its action upon pistons, valve stems, etc., is like that of oil, preventing the wear; and by these testimonies I should judge that it would be a very good article, provided it will prevent the formation of scale. There has been no experiments made as to that up to this time in this country, but there are now experiments going on.

This Steatite Talc is insoluble. It is also incombustible, and has no chemical or corrosive action on steam boilers, steam engines, or metals of any kind. It simply prevents the adhesion of calcareous and other deposits to the inner surfaces of the boiler plates, the flues, or tubes, and acts only as a division, without changing in

any way the normal condition of the steam boiler in regard to evaporation.

The testimony below by Marie, Chief Engineer of the Paris, Lyons, and Mediterranean Railways, who represents an interest (we understand) owning 1,700 locomotives, will serve to illustrate further evidence of its merits.

PARIS, November 28, 1872.

To Messrs. Vigier and Donnet:

GENTLEMEN—For eighteen months we have used your Steatite Talc for the boilers of the Rhone & Mount Cenis Railway, which are fed with extremely incrustating waters. The experiments were entirely satisfactory with the waters of the whole section. Our new boilers, as well as those having already been in use, were, through the action of your Steatite Talc, relieved from the solid deposits therein accumulated, and have ever since been preserved from incrustation while they were submitted to its action; but on ceasing the use of your remedy for a short time, say one month only, fresh incrustations were immediately formed again.

The addition of Steatite Talc to the water feeding new steam boilers, not only prevents incrustation therein, but it has also the effect of destroying incrustations already accumulated in boilers having been in constant use for several years, such as those in use at the depot at Chambery. The old incrustation receiving no fresh accumulations became, in a short time, detached from the inner surfaces of the boiler, and were carried off by washing or by blowing out the boiler occasionally. We have also observed that all our steam engines that are supplied from boilers wherein the Steatite Talc is used, work with less friction in the piston and steam valves. The surfaces of the cylinder and valve seats have attained an unprecedented polish; the stuffing boxes on piston and valve rods last much longer than before, and the engines work smooth, without any perceptible noise. We have therefore decided to continue the use of your Steatite Talc on our locomotives, and also to apply the same on all our stationary and portable engines.

[Signed.] MARIE,
Chief Engineer of the Paris, Lyons, and Mediterranean Railways.

We have a communication from W. Milner Roberts, Chief Engineer of the Northern Pacific Railroad, saying that an American analysis of the Steatite Talc has been carefully made, which corresponds exactly with the foregoing.

The following from L. S. Young, General Master Mechanic of the

Cleveland, Columbus, Cincinnati & Indianapolis Railway, will illustrate the large accumulation of scale with which some roads have to contend:

CLEVELAND, OHIO, March 17, 1874.

H. A. Towne, Esq.:

DEAR SIR—In answer to some of the questions contained in your circular, I would say: I have been using Lighthall's Anti-Incrustator for the past ten months in one locomotive boiler as preventative. The boiler was thoroughly cleansed, had new fire box, and a set of new iron flues. After eight months' constant service on freight, I removed two flues from near the center of the boiler, and found them comparatively clean; a thin soft scale, probably the thickness of paper, was all that was on them. The crown sheet and stays were all in good condition. In fact, there was no scale worthy of note upon any part of the boiler inside. At the end of ten months I again examined the crown sheet, with a like favorable result.

The boiler is of the same construction as many others in use on this line, and has received the same treatment as all other boilers, excepting it has received about 4½ pounds of the Anti-Incrustator at each washing.

With other boilers like this, that have run from twelve to fourteen months, we find it necessary to remove one-half or all the flues, crown bars, and sometimes the crown sheet, in order to clean them thoroughly. The flues will have a scale from one-eighth to three-eighths thick, and sometimes will be *connected* together in one *solid mass* for nearly the whole length of the boiler. I am using the same preparation in two stationary boilers with apparent good results, but am not prepared to give you the figures at this time.

I do not think it practical to purify the water before entering the boiler, nor is it possible to obtain rain water in sufficient quantities for lines with heavy traffic. If we could obtain rain water before it comes in contact with the ground we should have no trouble with scale in our boilers.

[Signed.] Yours, etc.,

L. S. YOUNG,
General Master Mechanic.

A large majority do not recommend the use of boiler compounds, but in the absence of a better remedy it is probable they may be used to advantage in some cases, providing the article *will* remove and prevent the formation of incrustation without injury to the boiler.

But a proper use of them, which will insure a clean boiler, would

involve considerable expense; first, on account of the cost of the article itself; and secondly, by reason of the difficulty of removing the sedimentary deposit in the cylinder part of the boiler. If they are to be used at all, their introduction into the boiler must be followed up at regular intervals, and means provided for washing through the front end with force pump until the sediment is all removed, and this *physicking* process must continue as long as water is used containing such impurities.

Your Committee would not recommend the use of any compound until it has been submitted to a competent chemist (who, if desired, may be appointed by the railway company) for analysis, and the result must bear the testimony of said chemist under oath.

RESERVOIRS.

Concerning the storage of rain water, we have the following from Mr. Charles R. Peddle, Superintendent of Motive Power and Machinery of the Terre Haute & Indianapolis Railway, in reply to Question No. 2 of the circular:

"Reservoirs have been formed on the western division of this line where the natural depression of the land and the surface drainage favored their location, and instead of putting a culvert through the embankment, it was made sufficiently wide to resist the pressure of the water safely, and puddled on the water side. Side ditches were made parallel to the track of sufficient capacity to carry off the water in case of an overflow. Last year a reservoir of this kind was made near St. Elmo, with a capacity of 5,000,000 gallons, and the land not being sufficiently depressed, was excavated by plowing and scraping, and the trestle in railroad embankment, which formerly afforded a passage to the water was filled up, and a surface of four acres is now covered with water to an average depth of four feet.

"The principal cost is the purchase of the land required. The work, when the location is suitable, is not very expensive.

"The reservoir referred to cost: Land, $100; grading, $385; planking, $20; teaming, $100; total, $605. The land adjoining should not be tilled, but sown in grass, otherwise the water is liable to be muddy after rains."

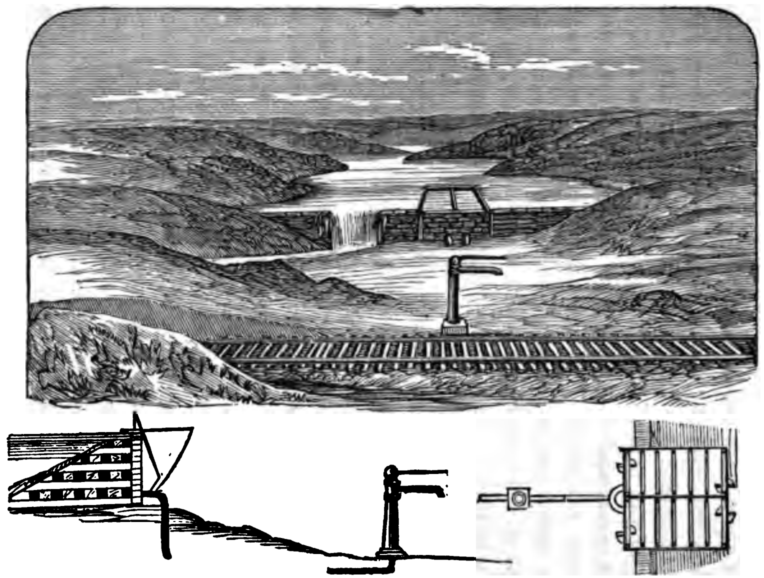
Mr. W. A. Robinson, Superintendent of Machinery of the Great Western of Canada; J. H. Setchel, of the Little Miami, and other leading Master Mechanics, recommend the use of reservoirs, while some do not believe it practicable.

Your Committee is prepared to reiterate their favorable opinion of this practice, as expressed last year, and they believe it not only practicable, but entirely consistent in localities where the natural features of the district renders a sufficiency of water available. In order to find the required dimensions of reservoirs to meet the demand of the traffic, it will be necessary to ascertain the excess or deficiency of the available rain fall for each month, after the demands for consumption, evaporation, leakage, etc., are deducted. The average evaporation is variously estimated from sixteen to twenty-six inches annually, that of the summer months being about double that of the winter ones. The amount of water required for the supply of each engine can be approximately reached from the figures in the report of last year. Such reservoirs as that spoken of by Mr. Peddle, and to which particular kind the foregoing alludes, are so cheap and simple that no objection can be raised on that score.

While the water from such a storage is unquestionably superior to well water for locomotive use, it can not be entirely free from the salts of the earth which underlie its bed, besides during a season of heavy rain and high water it must become more or less contaminated with mud and other floating impurities, all of which should be gotten rid of in some way before the water is taken into the boiler. Another objection to the large shoal reservoirs is the loss of water by evaporation, which may in some localities equal the rainfall itself; but whenever the fall is equal to that in the Middle, Eastern, and North-western States, little fear may be entertained as to the success of this mode of storage. The average annual rainfall throughout the above sections, as near as we can ascertain, is about forty-one inches. The evaporation of deep water is considerably less than that of shoal, but we have not been able to find authority for the exact ratio of this discrepancy; be that as it may, even ordinary reservoirs should be made as deep as possible.

An ordinary reservoir, with a capacity of 5,000,000 to 10,000,000

Sketch No. 1.



SURFACE DRAINAGE RESERVOIR FOR RAILROAD USE.

gallons, for the storage of both rain and surface water, in a favorable locality, like that represented in *Sketch No.* 1, furnished by the Committee, including two settling tubs or flooms, will cost not to exceed $4,000, and whenever the locality proves to be as favorable as represented, the water crain may be employed to the most economical advantage.

Owing to the great loss of water by evaporation and percolation through the earth in reservoirs already referred to, and its contamination with impurities by reason of its direct contact with the earth, your Committee are inclined to favor structures of a more substantial character, similar to that referred to last year. The same form, or a similar one, according to facilities afforded in the locality may be employed, but it should be scraped out to a considerable depth, say twenty to thirty feet, for at least the size of an acre, with a sloping surface leading to it, which will catch and maintain the supply required.

According to the last report, with a rainfall of forty-one inches, a catchment surface of four acres every twenty miles would supply the heaviest traffic.

The surface may be puddled, tiled, brick or stone lined and cemented, or planked, according to circumstances. The expense of such a reservoir would range from $7,000 to $15,000, the excess or decrease depending entirely upon the size of the structure and the facilities afforded for its location. At terminal stations, where a large supply of water is required, it may be conveyed a long distance from such reservoirs, and prove far cheaper in the end than the use of inferior water from expensive wells.

Your Committee still believe that the only certain and reliable mode of overcoming this evil is to purify the water before its introduction into the boiler; and, from their investigations, viewing the case as it now stands, they are prepared to recommend the following general rules:

First. The purest water should at all times be selected. That which contains the least impurities which form incrustations, rain and surface water, is especially recommended whenever it can be gathered to advantage, and means provided for settling or filtering,

so as to prevent the deposit of mud and other floating impurities in the boiler.

Second. Owing to the fact that no panacea can be found for all the incrustation diseases, it is evident that if it is to be cured by remedies at all, a diagnosis of each case must suggest the proper treatment.

Third. That each railway company interested should submit a specimen of the various kinds of water along its line to an expert, who shall confine his examination to the deduction of the injurious substances, and not to the absolute purification of it, beyond the necessity of the case in question. For some years the Pennsylvania Railroad, and also the Reading Railroad, have found it advantageous to submit the water to an expert, who tests for certain things only, and frequently a well pronounced unsuited is abandoned, and one dug near by may prove better adapted to the purpose. Each case requiring a remedy must likewise bear its own testimony.

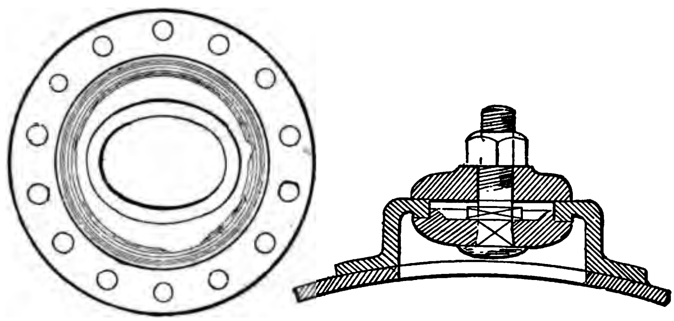
Fourth. That a committee of three, consisting of two members of the present committee and a competent chemist, be appointed by this Convention to confer with one or more railroad companies with a view to a practical trial of both Dr. Rogers' and Dr. Clark's process of purifying water for locomotive use, the expense to be borne by the company receiving the benefit.

Fifth. That reliable boiler compounds may, in bad cases of scaling, be used to advantage when the circumstances are such that the water can not be easily purified before entering the boiler. This treatment must be followed up with frequent and thorough washing, otherwise little if any benefit can be expected.

Sixth. We find that roads which realize the greatest trouble from incrustation and mud advise the use of the mud drum. Mr. Peddle, of Terre Haute & Indianapolis Railway, thinks a hand hole, as represented in *Drawing No.* 2, which he has used for some time, is equally as good as a mud drum and much cheaper, but your Committee are inclined to favor the cast-iron drum now in successful use on the Hannibal & St. Joseph Railroad, as shown in *Drawing No.* 3, on account of the benefit derived from the use of the blow-off cock, besides affording a convenient access to the boiler while undergoing repairs.

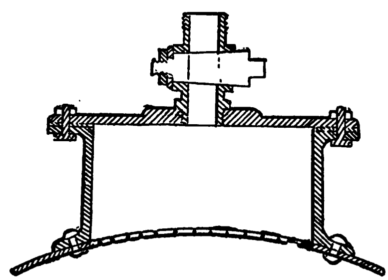
Drawing No. 2.

HAND HOLE IN FRONT OF BOILER.



Drawing No. 3.

MAN HOLE, MUD DRUM, AND BLOW-OFF COCK.



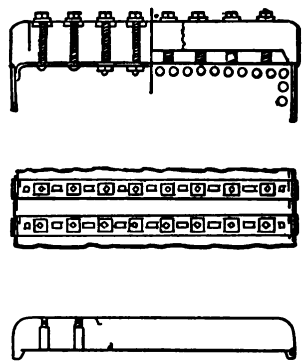
In order to keep the cylinder part of the boiler clean, the blow-off must be used daily; also blow-outs in leg and other parts of the boiler should be kept in order and used often. Crown bars should have at least one inch clearance above the sheet, and should be fastened without thimbles.

We submit herewith (*Drawing No.* 4) a good plan by L. H. Waugh, of the Kansas Pacific Railway, with description.

Drawing No. 4.

SOLID BAR.

Mode of attaching Crown Bars as adopted by the Kansas Pacific R. R.



When the ordinary skeleton or double crown bar is used, the sides are connected by pieces of iron or steel, about two inches square and ⅞ inches thick. This size, however, may be varied as circumstances may require. These pieces of iron or steel are located between the inner sides of the crown bar, about 1½ inches apart, and firmly attached to the inner sides of the crown bars by welding or otherwise, and extending through the length of the bars. In the center of these iron or steel connections are vertical screw-threaded perforations, about ⅞ inches diameter, and like perforations through the crown sheet, screw threaded and corresponding with the above mentioned holes in the bars. A headed screw bolt, threaded its entire length, is screwed through the crown bar and into the crown sheet, by which they are firmly held together. These bolts are properly headed and the heads rest upon square pieces of iron through which they pass. The lower ends of the bolts are screwed through the crown sheet, and extend into the fire box sufficiently to receive nuts on their lower ends, which nuts must be firmly screwed up to the sheet, or the ends of the bolts may be riveted in the ordinary way under the plate. When the crown bars are not constructed as above described, but of one solid piece of iron, the perforations are counterbored from the bottom of the crown bar upwards to ⅞ inches from the upper side. The space from the upper side of the crown bar to the counterboring is threaded, as shown in the drawing, to receive the bolts.

Our experience in this method of attaching crown bars to fire boxes has demonstrated that it is far superior to any heretofore used. Engines No. 11 (freight) and 17 (passenger) have had the above described bars attached for over two years, and run 42,455 and 63,850 miles respectively, and show at this day (March 12, 1874) only a slight deposit of scale, scarcely one-sixteenth (1-16) of an inch in thickness. In connection with the above we use the customary wash out plugs, placed on each side of the boiler just above the surface of the crown sheet.

Yours respectfully,

L. H. WAUGH,

Superintendent of Machinery.

Owing to the exceeding length of this report, that portion of the subject pertaining to management of boilers will be deferred till another time.

H. A. TOWNE, *Northern Pacific*,
A. H. DECLERCQ, *International & Gt. North'n*,
H. ELLIOTT, *Ohio & Mississippi*,
COLEMAN SELLERS, *Philadelphia*,
T. W. PEEPLES, *Central of New Jersey*,
} *Committee.*

HORACE A. TOWNE, *Chairman.*

To the General Supervisory Committee:

The following, a communication from Mr. Jas. M. Boon, of Pittsburg, Fort Wayne & Chicago Railway, together with a sketch of a boiler designed to prevent the formation of scale, came too late to be embodied in the report on Boiler Incrustation. We therefore beg to submit his letter in full, and also recommend the publication of his newly designed boiler.

H. A. TOWNE,
Chairman of Committee.

FORT WAYNE, IND., April 16, 1874.

H. A. TOWNE, ESQ., *M. M. Northern Pacific R. R., St. Paul, Minn.:*

DEAR SIR—The circular of your Committee on the "Management of Locomotive Boilers," etc., came to hand, in answer would say:

1. For a road doing a heavy business with a large number of locomotives, I do not think it practicable to purify the water for locomotive boilers, because the amount of water required is so great, and the time necessary to the process so long, that to make it a success the device for the purifying would have to be on so large a scale and so expensive that but few roads would go to the expense. For a road with a small number of engines and doing a light business, I believe it would be economy to purify the water. The means to do so could not well be determined until an analysis of the water was made and the nature of the impurities developed.

2. I consider it practicable to store rain water in reservoirs. The form of reservoir would depend on the formation of the country. In

a hilly country reservoirs could be made by building a dam between two hills; this would be the most simple and least expensive. If the hills had elevation enough the tanks could be filled without any other machinery than valve and pipe. Have no idea of the expense of a permanent fixture of the kind.

3. I believe the use of rain water would entirely overcome the evil of incrustation. Even though the supply was not sufficient for continual use of the rain water, its occasional use would be very beneficial.

4. I believe water can be purified by chemical and mechanicnl means, but doubt that it can be done so economically as to come into general practice.

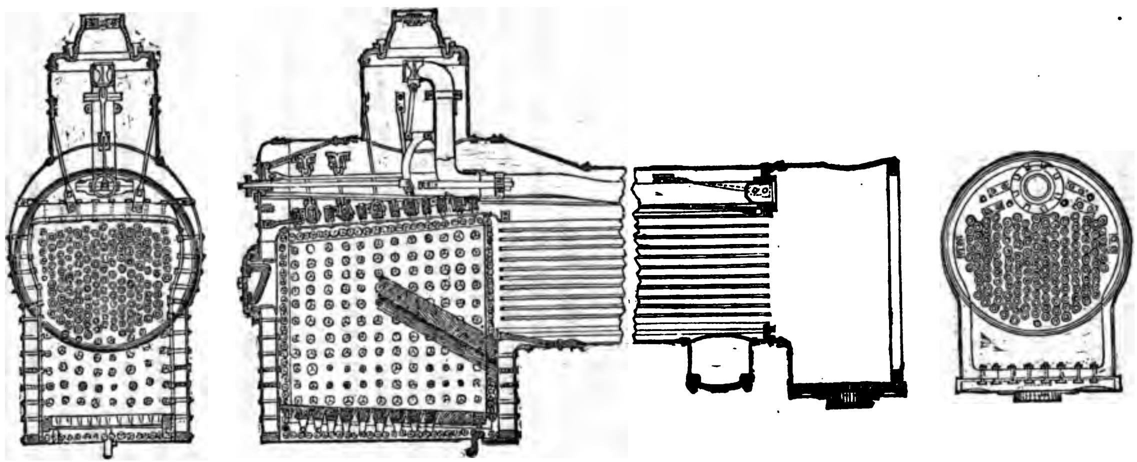
5. Have had considerable experience in the use of boiler compounds, and am fully satisfied that they are of no earthly use, and money spent on them is money thrown away.

6. No new facts have been developed in the use of the mud drum; continue to use it, and believe there is an advantage in so doing.

7. We wash the boiler out frequently with a powerful force pump. Every time the boiler is washed we put in one gallon of *crude* petroleum before the boiler is filled with water. This crude oil will not make the boiler foam; it will not prevent the formation of scale, but the formation will not be so rapid and will be more easily removed, the oil coating the iron. When the scale is formed the only way I know of removing it is to take the tubes out and clean them off, and put a man in boiler with pick to clean out. I know there is no failure in this plan of cleaning boilers and would recommend it.

8. I send by express with this a drawing of our standard boiler. This boiler I designed to prevent the formation of scale as far as possible; also to be convenient to get into to clean out. You will see the crown sheet is on an angle (this is not new, other boilers have been built in this way). My idea in making them on an angle was that the friction of the water on the angle as it washed forward and back would have a tendency to wash the deposit off. The crown sheet is also rounded from side to side, being 1½ inches higher in center than on sides. There is one inch space between the bottom of crown bars and top of crown sheet. There are no washers under the crown bars; the bolts are tapped into

Drawing No. 5.



STANDARD COAL-BURNING LOCOMOTIVE BOILER.
(Pittsburg, Fort Wayne & Chicago Railroad.)

crown sheet and screwed through the sheet and riveted on the inside of the fire box; the braces, throttle, etc., are arranged so as to make access to the crown sheet very convenient, nothing being moved but dome cover—top of throttle valve and throttle gear disconnected. Have had these boilers in use nearly two years; am well pleased with their performance; the scale collects very slowly and is easily removed.

MANAGEMENT OF STEAM BOILERS.

1. I think the pressure should be limited to 120 pounds to the square inch.

2. Think it is an advantage to provide boilers with water gauges.

3. Have never used low water detectors; would not recommend any that I have seen; they have a tendency to make the man in charge of the boiler careless by relieving him of responsibility.

4. Have had no experience with super-heaters.

5. Have always used wood, have no experience with any other.

6. Having had no experience, can not say.

Truly yours,

JAS. M. BOON,
Master Mechanic.

On motion of Mr. S. J. Hayes, Illinois Central Railroad, the report was accepted.

Mr. SEDGLEY, Lake Shore & Michigan Southern Railroad—I wish to offer the following resolution:

"*Resolved*, That the President appoint as early as possible a Committee on Subjects for Consideration during the coming year, and that any member having subjects to suggest present them to said committee before to-morrow at two P. M.

The resolution was adopted.

The President appointed as the committee under the resolution Messrs. J. SEDGLEY, Lake Shore & Michigan Southern Railroad; M. N. FORNEY, of the Railroad Gazette; and JOHN THOMPSON, Eastern Railroad.

THE PRESIDENT—If at any time members have subjects to offer and can not find the Committee, if they will pass the papers to my desk I will see that they are received by the Committee.

Mr. TOWNE, Northern Pacific Railroad—Mr. President, I would suggest in regard to the discussion of this report that it be deferred until to-morrow,

on account of the fact that Mr. Joseph G. Rogers is here in person, and has a paper prepared on the subject which he would like to read before the Convention. He has also apparatus for making some experiments which will probably be more interesting if the discussion is deferred until that time. The attention of the members of the Convention will be drawn out afresh, and we will probably get a more thorough view of the subject. If there is any thing else to come before the Convention, I would move that this discussion be deferred until to-morrow.

THE PRESIDENT—Please set an hour—say at nine o'clock in the morning.

Mr. TOWNE—Yes, sir; I accept the suggestion.

The motion was then adopted.

Mr. TOWNE—I would inquire further if there would be any objection to the reading of that paper by Dr. Rogers. He is not a member of the Association, but I intend to propose his name for membership.

The PRESIDENT—I would state, Mr. Towne, that all correspondence on local matters to come before the Convention should be referred to the Supervisory Committee, according to the resolution adopted this morning. The next business in order, gentlemen, is the report of your Committee on Machinery for Supplying Water to Tanks and Fuel for Locomotives.

THE SECRETARY—I would say, Mr. President, that I just let the Chairman of that Committee have the report for the purpose of consulting with members of the Committee just arrived.

THE PRESIDENT—That being the case, the next business in order will be the report of the Committee on the Best Form of Safety Valve or Method of Relieving Boilers from Overpressure, and the Best Way of Testing Pressure Gauges. The report is in the hands of your Secretary, who will read it.

Report of the Committee on the "Best Form of Safety Valve or Method of Relieving Boilers of Overpressure, and the Best Way of Testing Pressure Gauges."

To the American Railway Master Mechanics' Association:

GENTLEMEN—In reply to the Circular sent twenty-five answers were received, and these showed a considerable diversity of opinion in regard to the questions submittod.

To the first question Mr. L. H. Waugh replied that he prefers attaching both valves to the forward dome when the engine has two; but a general preference was expressed for one lever and one direct spring valve located on the cover of the dome over the fire box.

Those who expressed objections to lever safety valves, based them on their liability to be tampered with by the engineers; their ten-

dency to rust and corrode at the joints of the lever, which causes them to stick; an insufficient range of the spring by which the motion of the valve is restricted, and the liability of the roof of the cab to interfere with the free motion of the rod on the end of the lever.

The expression of opinion in regard to direct spring valves was, with few exceptions, in their favor. The grounds for this preference were stated to be their compactness and simplicity; the quick relief which they afford to an excess of pressure; their prompt closing when the pressure falls, and the fact that they are or may be made independent of the control of the engineer.

Mr. Wm. A. Robinson objected to them because "they become corroded from inaction."

Mr. James M. Boon said "I have never observed any advantage in a direct action spring valve. The disadvantages are they, or all I have seen, are easily tampered with and troublesome to keep adjusted when steam comes in contact with them. In my experience I have found that no spring will retain its stiffness when steam strikes or is in contact with it. I do not know what the action of steam on tempered steel is, but I *do* know that it will change the temper of the steel in a short time and finally destroy its elasticity."

These objections will be referred to by your Committee in reviewing the subject.

To the fourth question the answers were, with very few exceptions, to the effect that *no* injurious lifting of water was caused by the use of the Richardson valve—this valve being selected because its sudden lift or "popping" is more violent than other valves.

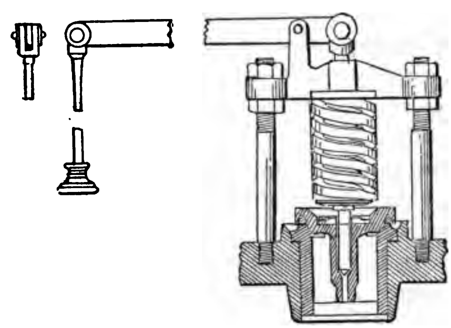
Mr. Reuben Wells said: "The effect of the popping can be but little different from suddenly opening the throttle valve, and it can be no more injurious to the boiler. The sudden popping has no visible effect on the steam gauge except a gradual fall of pressure until the valve closes again. A constantly varying pressure, especially when it takes a wide range, is more injurious to the boiler than a sudden lifting of the valves or opening of the throttle, from the fact that boilers are not well braced on the flat sides. A 'pop' on a dome will not materially affect the water level of the boiler if it has a proper amount of steam room."

To the fifth question the replies showed a considerable diversity of opinion; Mr. S. M. Philbrick being satisfied with two valves, each two and one-eighth inches diameter, while Mr. A. Gould prefers two valves, each four inches diameter. The general expression was for two valves three inches diameter, one a direct spring and the other a lever valve.

To the sixth question the answers were mostly in the negative. Mr. Wm. Fuller sent a tracing of an improved Richardson valve (*Fig. No.* 1), but the improvement is in the mode of applying the lifting lever and the important features are undisturbed. Mr. Reuben Wells in his answer sent a pen-and-ink sketch of a conical seated valve with a three-quarter inch bearing face; but this can hardly be called a *modification* of the *Richardson valve*, and will be referred to hereafter. Mr. J. L. White sent a pencil sketch of a valve with the seat beveled directly the reverse of the ordinary conical valve, and with a groove cut in the seat which is nearly covered by an extension of the valve. No statement was sent of the action of the valve, and as the reply was received too late for the Committee to experiment with a valve of that shape no report can be made upon it.

Figure No. 1.

POP VALVE AS APPLIED BY THE A. & Gt. W. R. R.



With the sixth question the subject of safety valves terminates; and, before proceeding to the other subject of inquiry, *Pressure Gauges*, your Committee will review the answers and also give the results of a few experiments made to settle certain mooted points.

The objection of Mr. Boon to direct spring valves—that the springs lose their elasticity by contact with the steam—can apply only to those valves, the springs of which are placed inside the dome, as steam escaping into the atmosphere does not exceed the temperature of two hundred and twelve degrees, and the springs are partially protected from the direct force of the steam by the valve itself. Neither does Mr. Robinson's objection—the rusting and corrosion of the springs—hold good in the case of *outside* springs when the engine is in daily use. Several valves examined seemed to have their springs coated with a black enamel which preserved them from rust. But springs located inside, as in the Anderson valve, *may* be ultimately affected by a temperature as low as three hundred and sixty degrees—the temperature of steam at one hundred and thirty pounds pressure—but your Committee have no experience which will lead to such a conclusion. There is no doubt however that such springs rust and become coated with lime, and that *this*, in the case of the volute springs of the Anderson valve, may cause friction and impair their elasticity. There is one other objection to the inside spring valves, viz.: the difficulty in grinding and adjusting them, as the dome cover requires to be taken off and the nuts are generally found so much corroded as to require splitting to remove them. On the other hand, a solitary argument may be urged in favor of this form of valve, *the engineers can not get at them.*

It is supposed by some that an ordinary safety valve loaded with a dead weight, either directly or by a lever, will relieve a boiler of all pressure over and above the number of pounds per square inch at which it is loaded.

This, however, is an error, and to demonstrate it an experiment was made with a shop boiler provided with a safety valve two and one-half inches diameter, with a conical seat of about three-sixteenths of an inch, the diameter of the bearing seat being two and three-quarter inches. The valve was loaded with a fifty pound weight placed at such a distance on the lever as to allow the steam to blow off at or near sixty-five pounds.

The valve was in good order, and had been examined the night previous, and the pins at the joints of the lever had been taken out and cleaned of rust. The boiler was thirty feet long, forty inches diameter, with two fourteen and one-half inch flues, and a grate sur-

face of seventeen square feet. At the dinner hour the fire was not suffered to run down as usual, but was forced by using chips from the wood-planing machine, and the engine was stopped.

The valve commenced blowing at sixty-three pounds, blew hard at sixty-four, and gradually went up to seventy-two and one-half pounds, beyond which it was found impossible to raise the pressure. The valve lifted eight-tenths of an inch. The area of the valve is nearly up to the requirements of the Committee of the Franklin Institue for a boiler carrying that pressure, viz.: $\frac{31}{100}$ of an inch for every square foot of fire grate.

The only rational explanation of this increase in pressure, about sixteen per cent., appears to be this: As soon as an orifice is made for the discharge of the steam by the raising of the valve, the pressure in the vicinity of the opening not being confined on the sides ceases to press upward on the valve as it escapes into the atmosphere. The higher the valve lifts the greater is the relative loss of pressure, so that the pressure must accumulate much higher in the boiler to maintain the valve at its proper height than the load on the valve. The effective lifting area of the valve appears to have been diminished by the amount of the area of the orifice made by the lift, which is $\frac{63}{100}$ of an inch. The area of the valve is $4\frac{9}{10}$ of an inch.

If we multiply this by the load per inch on the valve (sixty-three pounds), and divide by the area of the valve less the area of the orifice, $4\frac{37}{100}$ inches, it will make seventy-two pounds, the gross pressure nearly. This may only be a coincidence in this case, and not a law governing all similar cases, but would seem to be worth a more extensive and accurate investigation than your Committee has been able to give the subject.

In order to determine what sized orifice would pass all the steam made in a locomotive boiler of average size, with a good fire and the blower applied at intervals, an engine was selected with sixteen by twenty-four inch cylinders and a grate surface of fourteen square feet, and the injector pipe was removed from the cock, screwed into the top of the dome, and a thin plate, having a five-eighth inch hole, was screwed fast to the end of the cock and made steam tight at the joint by a rubber gasket. This orifice was found to be insufficient, and was gradually enlarged by standard reamers one-sixteenth of an

inch at a time, until it was made fifteen-sixteenths of an inch in diameter, when it was found that the steam escaped as fast as it could be made, so that it was decided that an orifice of seven-tenths of a square inch would be sufficient. Every locomotive should have two safety valves, either one capable of passing all the steam possible to be made, in case one should be deranged, and the area of the discharge should not be less than *seven-tenths of a square inch* for each valve.

We have shown previously that the ordinary dead weight safety valve will not relieve the boiler of steam as fast as it can be made without the pressure rising above the rated load on the valve. This is aggravated in all plain conical seated valves held down by a spring, either direct or by a lever, by the fact that the tension of the spring increases as the valve lifts. In general the larger the valve the less will this overpressure be, because the valve is not required to lift so high to pass a given amount of steam, and consequently does not increase the tension of the spring so much, and because also the effective lifting area is larger in proportion to the escaping area, the area increasing much faster than the circumference as the valve is enlarged. So that for a valve of this kind four inches is better than a smaller diameter as preferred by Mr. A. Gould.

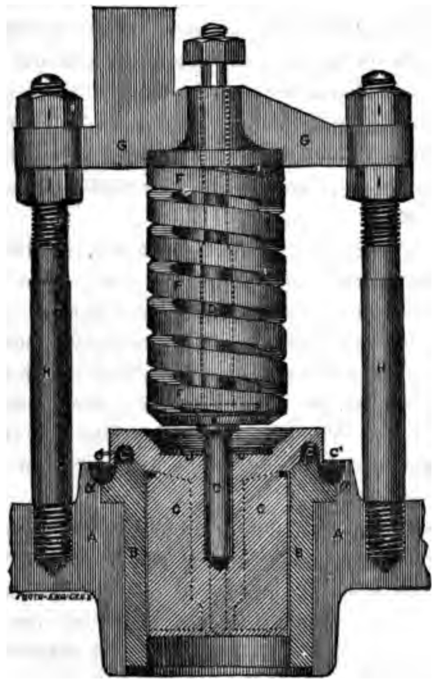
With what are known as reaction valves, of which the Richardson is the best type, the case is different. In this valve the steam in escaping strikes a curved rim on its outer edge and is deflected into another groove on the outer edge of the seat. This action and reaction of the steam lifts the valve higher than it would if it had an easy and straight-forward escape into the atmosphere.

We have seen that an orifice fifteen-sixteenths of an inch diameter will discharge all the steam an ordinary locomotive boiler will make. A valve will pass over the seat all the steam or water which can pass through the orifice it covers if it lifts one-fourth its diameter, so that a large valve is not required when the lift is ample.

A test was made with a Richardson valve on the engine referred to previously. The valve had been in use for some time and had not been recently disturbed. In order to register the amount of the lift accurately, a light lever was attached to the dome cover at one end, and rested on the valve spindle a short distance from the end, while the other end was movable and made to range with a fixed scale laid off in tenths of an inch. In the experiment one of the

RICHARDSON'S PATENT SAFETY VALVE,

Referred to by Committee, and too well known to need further description.—Secretary.



safety valves was fastened down securely so as not to operate. The fire box was filled nearly to the fire door with wood and the blower put on. The valve went off with an explosion or "pop" at one hundred and thirty-five pounds; the steam fell rapidly to one hundred and thirty pounds and the valve closed suddenly. This was repeated several times with the same result. The valve lifted $\frac{18}{100}$ of an inch and gave an area of orifice of nearly nine-tenths of an inch; about two-tenths of an inch larger than was actually necessary to discharge the steam. In making this and subsequent calculations allowance is made for the difference between the lift and the opening as from the angularity of the seat the opening is about three-tenths less than the lift.

From this experiment it would appear that Mr. S. M. Philbrick, who says that he uses the Richardson valve, is not much out of the way in preferring a valve two and one-eighth inches diameter, as the regular Richardson valve, which passes twenty per cent. more steam than can be made, is only two and one-quarter inches diameter.

The second experiment was tried on an engine, of same dimensions as the previous one, having one direct volute spring valve three and one-half inches diameter, and one lever valve three and three-eighth inches diameter, held down by a spring balance with a releasing apparatus.

The lever valve was first fastened down and the fire box filled one-fourth with wood and the blower put on. The valve went off gradually at one hundred and twenty-four pounds, the pressure on the gauge went up to one hundred and thirty-six pounds, and there remained and could not be increased without additional firing. The boiler was cooled off and the valve closed at one hundred and twenty-four pounds. The lift of the valve was $\frac{85}{1000}$ of an inch, which gave an area for escape of $\frac{27}{100}$ of an inch, a little less than two-fifths of the required area.

This valve was then fastened down and the lever valve tried without the indicating lever, and the lift was measured on the balance case. The valve went off quietly at one hundred and thirty, and the pressure went up to one hundred and forty-five, when the fire was cooled down and the valve closed at one hundred and twenty-five pounds. The end of the lever only moved one-sixteenth of an inch; but the valve no doubt sprung the lever as the opening due that amount of lift was too insignificant to pass the steam as fast as it did. Both these valves had conical seats with three-sixteenths of an inch bearing surface.

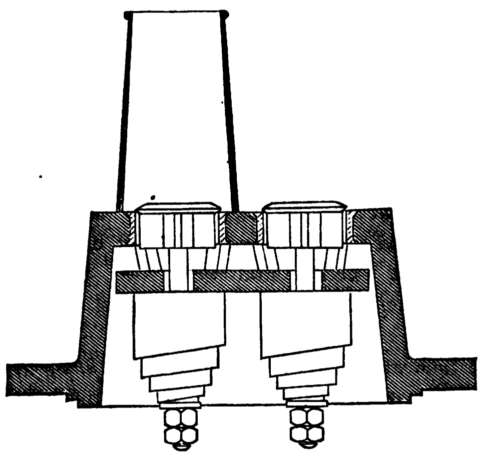
The third experiment was on an engine same size as before, fitted with two Anderson valves (*Figure No.* 2) three and one-half inches diameter, and held down by volute springs inside the dome cover. The outer diameter of seat was three and three-quarter inches, giving a conical bearing of about three-sixteenths of an inch; fire box about one-fourth full of wood and blower put on—one valve had been fastened down. The steam commenced blowing gradually at one hundred and twenty-seven, went up to one hundred and forty,

and the fire was then cooled down when the valve closed at one hundred and twenty-five pounds. The valve lifted $\frac{4}{100}$ of an inch, and gave an effective opening of $\frac{31}{100}$ of an inch, not one-half of the opening required.

Figure No. 2.

ANDERSON'S PATENT SAFETY VALVE,

Referred to by Committee.



The other valve was then released, and with both valves at work the steam commenced blowing at one hundred and twenty-seven and ran up to one hundred and thirty-five, and remained at that pressure until the damper was closed and the fire cooled off when the valves closed at a pressure of one hundred and twenty-five pounds. It will be seen from this that the combined valves were not able to prevent the steam from raising eight pounds with a light fire, and were not adequate to pass the steam which could have raised at an increase of pressure of thirteen pounds.

The fourth experiment was made with a valve two and one-fourth inches diameter, but with a much enlarged conical seat, the outside diameter of which was three and one-fourth inches, giving a bearing of three-fourths of an inch. Only one-eighth of an inch of this was allowed to bear on the seat; the balance, from the seat outward,

being turned off so as not to touch. A sketch of this valve was sent by Reuben Wells, who has such valves in use. The valve was held down by a spring same as Richardson's.

The conditions being same as before, the valve went with a "pop" at one hundred and twenty-five; the pressure rose to one hundred and thirty-one, and was stationary at that point until the fire was cooled off and the valve closed at one hundred and thirteen pounds. Another trial gave one hundred and twenty-six, one hundred and thirty-two and one-half, and one hundred and thirteen pounds at the respective points.

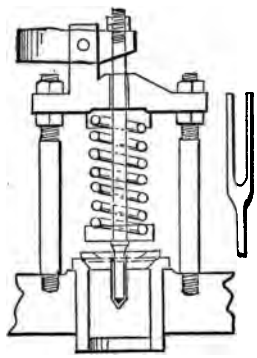
At the last trial the valve lifted $\frac{8}{100}$ of an inch, giving an effective discharge area of nearly four-tenths of an inch, a little over one-half the amount required to pass all the steam which could have been made. The valve was put in the lathe and one thirty-second of an inch taken off the beveled face outside of the bearing portion; it was then put back and a trial was made, same conditions as before; valve went off at one hundred and twenty-two, pressure ran up to one hundred and thirty-five, and the valve closed at one hundred and sixteen pounds.

The beveled face was then turned entirely off down to the bearing face of three-sixteenths of an inch, and on trial the following was the result, the conditions being the same as before: Valve lifted at one hundred and seventeen, the pressure went up to one hundred and thirty-five, and the valve closed at one hundred and fourteen pounds. The lift in the last trial was $\frac{65}{100}$ of an inch, somewhat less than the previous one.

The fifth experiment was made with two valves two and one-fourth inches diameter (*Figure No.* 3), made with a square recess outside the conical seat, on both valve and face, and held down by a coiled steel spring. This valve has been in use for some time on the Terre Haute & Indianapolis Railroad, and was supposed to be an *improvement* on the Richardson valve. With both valves in operation, and a good fire aided by the blower, the two valves went off simultaneously at one hundred and twenty-eight, the pressure rose to one hundred and thirty-nine, and fell to one hundred twenty-two pounds, when the valves closed after the fire had been cooled down.

Figure No. 3.

T. H. & I. R. R. SAFETY VALVE.



Lift of each valve was $\frac{5}{100}$ of an inch, making discharge area of both valves barely sufficient to relieve the boiler if the fire had been forced. The valve was voted "*not* an improvement on the Richardson."

The sixth and last trial was made with a valve made by Case & Baillie of Detroit. This valve is two and one-fourth inches diameter, and has a *flat* seat with a slight bevel given to the outer edge of the valve, which is two and three-fourths inches diameter. A screw thread is cut on the outer rim of the seat, and a collar or false seat, which is cut open at one place and held together by a clamping screw, is screwed down upon it so as just to clear the valve. In adjusting this valve the collar is raised until it touches the valve, and it is then run down a quarter turn and the clamping screw set up tight with a screw-driver.

With about one-third of a wood fire, and the other conditions same as before, the valve went off with a "pop" at one hundred and ten, and the pressure went up to one hundred and twenty-five, and remained stationary at that figure. The fire was then cooled off and the valve closed at one hundred and seven and one-half pounds.

The valve lifted one-tenth of an inch; and if no account is taken of any contraction caused by the beveled collar, which is an uncertainty, the area of the discharge orifice will pass all the steam which can be made at an increased pressure of fifteen pounds.

This closes the experiments made, which demonstrate conclusively that the Richardson valve *alone* of those tried fills the requirements of a good safety valve in promptly *reducing* the pressure after it has exceeded a certain limit, instead of allowing a dangerous accumulation, the fault of many other valves, and also in promptly closing without allowing an undue waste of steam. There is one objection, however, inseparable probably from valves of this kind, and that is the infernal din which accompanies its sudden discharge of steam, which makes this valve a nuisance and a terror in towns and villages and particularly in passenger stations.

Your Committee has no knowledge of the Ashton or the Prescott valves (*Figure No.* 4) referred to by some of the members, and consequently are unable to report upon their merits.

Mr. Wm. S. Hudson sent a tracing of a direct spring valve, (*Figure No.* 5) with a hemispherical seat, and a novel sealing arrangement for the prevention of tampering with the nuts by unauthorized persons. This and other tracings are appended to this report. There did not seem to be any feature in the valve which would produce better results than the plain conical valve, and therefore it was not deemed best to try any experiments with it.

In taking leave of this subject a few suggestions, prompted by the investigations made by the Committee, will not be out of place.

All safety valves should have brass seats as a safeguard against rusting and corrosion. When two plain seated valves are used a less diameter than three and one-half inches should not be allowed. Lever valves with such spring balances as are frequently furnished by engine builders are *not* safe, and are a delusion and a snare to those who trust in them. Valves with springs inside the boiler are not advisable. Non-tampering arrangements should be used on all direct spring valves.

PRESSURE GAUGES.

Three questions were propounded in the circular of the Committee relating to pressure gauges. To the first one, "What is your method of testing pressure gauges? a large majority replied, "By the ordinary hydraulic pump and test gauge."

Messrs. W. A. Robinson and A. Wilson use a mercury column, but give no details of the apparatus.

Figure No. 4.

PRESCOTT'S SAFETY VALVE.

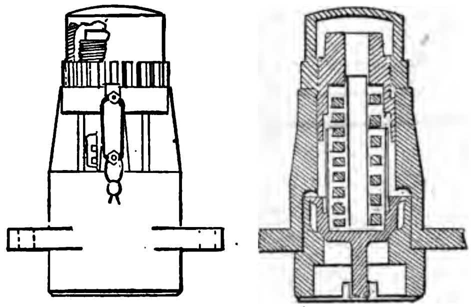
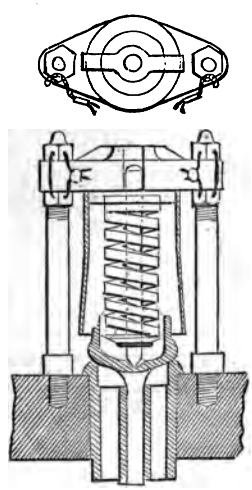


Figure No. 5.

LOCK-UP SAFETY VALVE.

(Rogers Locomotive and Machine Company.)



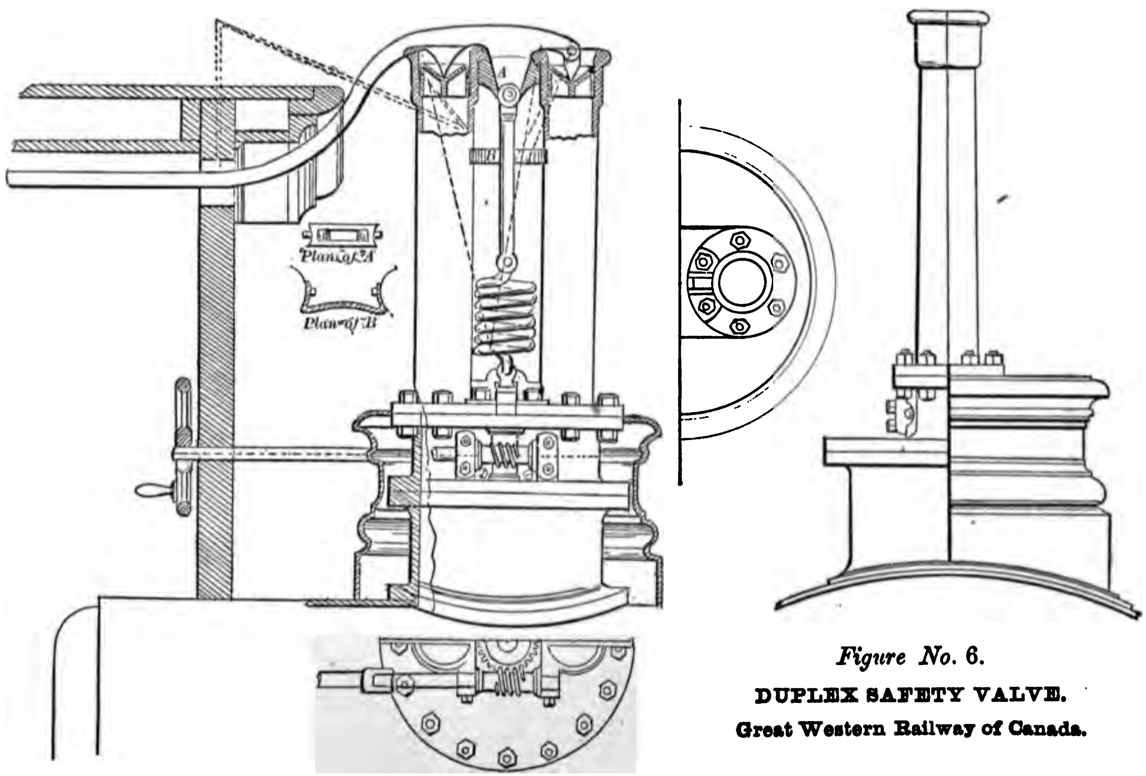


Figure No. 6.

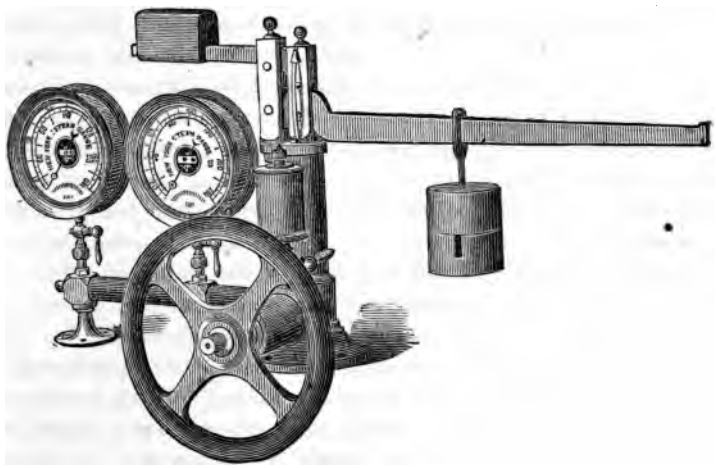
DUPLEX SAFETY VALVE.

Great Western Railway of Canada.

Mr. W. S. Hudson uses and highly recommends a testing machine (*Figure No.* 7) provided with steelyard and scale weights, made by Davis & Co., New York City, a drawing of which is annexed.

Figure No. 7.

DAVIS & CO.'S TESTING MACHINE.



Mr. T. W. Peeples tests his gauges "at intervals of four weeks by record;" Mr. Wm. H. Ellis at "intervals of one month," and Mr. William Fuller "every three months." The remainder generally report that their practice is to test a gauge when the engine to which it is attached lies in for repairs, or when it is reported by the engineer, or when there is reason to suppose that it requires adjusting.

In reply to the ninth and last question, "What make of gauges gives you the best satisfaction? and state the advantages of the same," the expressions of opinion were about equally divided among the various kinds of gauges in general use.

Mr. N. E. Chapman, however, said: "I am unable to give any decided preference to any of them, as they all, or at least the several kinds I have used, give us a great deal of trouble. We find one that seems upon trial to give good satisfaction; but after using them awhile they begin to give a great deal of trouble, require continual

repairs, and very little dependence can be put in them, and unless they are accurate I consider them of little use."

Mr. R. Wells was of the opinion that "all are so nearly alike that I can not tell any difference—all are poor enough."

Mr. J. M. Boon said: "I have used nearly all the different makes of steam gauges, and see but little difference in any of them. I do not permit the engineers to carry steam by the gauges, and have never seen one that I consider perfectly reliable. Steam must be carried by the spring balance and lever, and the gauge used to regulate the fire by. I know this is different from the general practice, but am satisfied that it is the safest. I have known gauges to cease to work from water depositing sediment in them; from springs, both gum and steel giving way; from pipes freezing, and from many other causes by which the gauge would show greater or less pressure. I believe that the safety-valve lever, with a good spring balance permanently secured, without any fixtures for letting off steam or pulling down, to be the best and safest arrangement that can be made to carry and regulate the steam on a locomotive boiler."

In addition to the circular to the members of the Association, a letter was addressed by the Secretary to each of the prominent makers of steam gauges, requesting such information in regard to the manufacture, operation, and mode of testing their gauges as would be of service to the Committee in making out a report. A few responses were received containing the desired information, and also a few advertising circulars, of which no use could be made by the Committee.

A very brief description will therefore be given of the several gauges in general use, and we will endeavor to point out the defects which are developed after a lengthened use, rather than to show up the good points claimed by the manufacturers.

The pressure gauge is one of those valuable, and now considered indispensable, appliances which have been added from time to time to the locomotive engine, and which have made the work of the engineer so much safer and less laborious than it was a quarter of a century ago, when, as many of you will remember, a single-lever safety valve, held down by a well-worn Salter's balance, which, when the occasion called for it, was screwed down "solid," was the only

check or safeguard which the engineer had against overpressure in his boiler. Your Committee therefore put in a plea for this useful appendage to the locomotive boiler, and do not think that it deserves the wholesale condemnation of the experienced men whom we have recently quoted.

No one, however, who has been through a railroad master mechanic's store room, and seen the pile of rejected pressure gauges usually found there in all stages of debility, can deny that a great many worthless gauges are made and sold; and when it is borne in mind that the most of these cheap gauges find their way to the mills and agricultural machinery in the rural districts, can there be any wonder that so many *mysterious* explosions occur?

Pressure gauges, like clocks and watches, sometimes get out of order and require frequent and systematic testing and correcting, and occasionally a renewal of their wearing parts. A first-class gauge, and there are such, rarely requires renewal of the part exposed to wear. A poor gauge requires it continually, although at first it made a good record.

The steam gauges in use in this country may be divided in four distinct varieties, according to their plan of construction.

The Bourdon gauge is the oldest and the first variety noted. In the construction of this gauge advantage is taken of the tendency of a curved flattened tube, closed at one end, to straighten out or uncoil when the pressure enters it from the open end. Accordingly the tube is connected with the supply pipe and the case at one end, and the other allowed to play loose, but is connected by a rack and pinion to the hand or pointer. This makes a very sensitive and accurate gauge for certain purposes, but after extensive use on locomotives the following defects show themselves: The jarring motion of the engine causes the loose end of the spring tube to vibrate continually, and this in turn makes an increased disturbance of the hand, so that it is difficult to read the correct pressure on the dial, and the rack and pinion are worn out by this constant movement. The internal surface of the tube is soon coated with a deposit from water containing lime, and this accumulates and destroys the elasticity of the spring. The water in the spring has been known to freeze in cold weather and burst the tube. The constant vibration

of the spring tube, combined with the effects of high pressure, cracks it on the edge, and as it is impossible to repair it without affecting its elasticity a new one is necessary, and the gauge must be sent back to the maker.

The American Steam Gauge Co. manufacture what they consider an improvement on the original Bourdon gauge. In this gauge, which is known as "Lane's" improvement, the tube is fastened to the case and the supply pipe at the center of its length, and the turned up ends are both allowed to move, and are connected to the hand by a lever in such a way as to avoid oscillation. It is also claimed that no deposit of lime takes place in the tube, as there is no lodgment of water in it. The liability of the brass tube to give way on the edge seems not entirely to be done away with.

The "disc spring" variety of gauge comes in for a notice. The Shaeffer & Budenburg gauge, we believe, is the original type of gauges of this construction. A corrugated circular steel disc is held fast by its outer edges between flanges, and the pressure on the disc moves a rod which is connected to the hand by a quadrant rack and pinion movement. This gauge, no doubt, has been much improved in the details to enable it to compete with more modern gauges, but one of your Committee has a lively recollection of the brief and unfortunate career of a number of them, which were placed on a Western road some eighteen years ago.

The great difficulty with this and all disc spring gauges is to get steel or brass of the right temper to stand the great pressure on the disc without bending or cracking. In addition to the severe strain on the steel plate it was exposed to rust and corrosion, which also assisted in destroying it. This is prevented now by plating with silver, nickel, or some cheaper non-corrosive metal.

The Blake and Post & Co. gauges are of this variety, and have the disc placed vertically inside and against the back of the case. They differ from each other only, we believe, in the form of the corrugations given the steel disc, and in some details of manufacture. In the Blake gauge the steel disc is corrugated *spirally*, and in the Post & Co. gauge, *radially*. The object of both is to give increased elasticity to the spring and lessen the tendency to crack. Both claim that they are very particular in selecting the best of steel for

these springs, and exercise great care in hardening and tempering them, as the durability and accuracy of the gauge depend in great measure upon the behavior of the springs. Instead of rubber a lead gasket is used between the outer edge of the spring and the bearing surface in the case, and a follower is screwed down on it with a long wrench. The gauges are subjected to a very severe test by heat and pressure before being finished and put upon the market.

The Belfield gauge has a disc spring made up of three thin plates of brass, held together and to the back of the case by screws. The plate on the pressure side is solid, the next one has a small circular hole in it, and the third a still larger hole—the intention, doubtless, being to strengthen the spring on the outer portion of it where it would be most likely to fail. A rack and pinion movement turns the hand. In practice it is found that, when the pressure acts on the disc, there is a slight movement of the plates one over the other, and that this in time is interfered with by an accumulation of dirt or verdigris, which causes friction and deranges the adjustment. The plates also receive a permanent set from the great pressure which acts on them.

As before stated, it is difficult to get brass of the *right temper* for springs exposed to severe strains such as disc springs receive. That there is a great want of uniformity in the spring brass used is shown by the very contradictory results obtained from gauges by the same maker at different times.

The "Wooten" gauge is somewhat similar to the Belfield gauge, and has a single brass plate of larger diameter. These gauges frequently give out at the soft solder connection between the disc and steam pipe, and the remarks just made will apply to it also.

The gauges of Brown Bros. and the New York Recording Gauge Co. are of the disc spring variety, but the Committee know nothing about them.

A third variety of gauges is that in which the pressure is transmitted through a rubber-cloth diaphragm to a plunger, lever, or spring which transmits it ultimately to the hand.

In the Ashcroft gauge the pressure acts through the rubber diaphragm upon a plunger working against a volute spring, which

works against an elliptic spring in the case. The motion is transmitted to the hand by a chain movement. The defects of the gauge, after use, appear to be mostly caused by the considerable motion of the plunger and rubber packing, causing the latter to leak in a short time; and this causes the volute spring to rust, and its elasticity is soon impaired, as shown by the gauge failing to record correctly. Nickel plating would partially correct this evil.

The Eastman gauge has a rubber diaphragm, acting on a lever attached to a spiral steel spring, working a rack and pinion movement. There is considerable vibration of the hand when in use, and the machinery is heavy and cumbersome. On the other hand the gauge is easily and cheaply repaired by a common hand, if the peculiar rubber used is obtained from the maker, and there is no delicate and expensive machinery to be renewed.

Holt's Cleveland gauge is worked with a large steel hoop spring, made fast to the inside of the case, unexposed and not liable to rust. A brass plunger resting on a rubber diaphram is made fast at its upper end to the spring and to a lever which works the chain movement. The plunger has a motion of only one-sixteenth of an inch to turn the hand to the highest point of pressure on the dial; thus there is very little wear of the packing. The spring being of liberal dimensions and of a good form to develop the most elasticity does not break or lose its set; if found at any time too heavy a simple adjustment is provided by moving a slide. The rubber is the only part which requires renewal, and will not last more than two or three years, but as this is inexpensive it is not a serious objection.

The Allen gauge is worked by a volute spring similar to the one on the plunger of the Ashcroft gauge. Movement, rack and pinion. The objection to the latter gauge, the rusting of the spring, applies also to this gauge.

The fourth and last variety of gauges is the "Drum Spring" gauge. Two brass discs are connected on their outer edges by a circular ring, the pressure forces the disc apart and a combined movement of the two plates is the result. The Buffalo gauge is the oldest and best known specimen of this variety. Two discs of spring brass, about one and three-eighth inches in diameter with a one-eighth inch ring interposed between, are riveted together near

the outer edge, and steam is introduced into this drum by a pipe in the center of the lower disc. The movement is taken from the upper disc of the drum by a cranked lever and transmitted to the hand by a rack and pinion. A spiral brass spring draws back the lever. Good material for the spring is everything in this gauge. If the spring retains its elasticity the gauge is a durable one. They occasionally fail, however, by reason of the cracking of the disc.

The Utica gauge, the only other gauge of this variety, has a drum spring larger than the Buffalo gauge and corrugated on the faces. The two discs are held together by a thin ring of the same material, which is flanged over on them and unites them without the use of rivets. The gauge is well made, and has a rack and pinion movement. The remarks as to the material used apply to this gauge as well as the Buffalo gauge.

This closes a cursory and very imperfect review of the construction and defects of the principal gauges in use.

The principal manufacturers use a forty foot mercury column. Mr. R. C. Blake sends a tracing of his apparatus with a description (*Figure No.* 8), and the Buffalo Steam Gauge Co. also send a report of their testing process, both of which are appended.

Description of R. C. Blake's Mercury Column.

A, water cistern; B, pressure pump; C, one of the mercurial cisterns of which they are six; D, seven glass tubes each one 7 feet 6 inches long; E, supply pipe receiving water from pump and distributing same through water pipe at F; G, cast-iron base in which glass tubes are cemented, also iron pipes which convey mercury from cisterns below up through glass tubes; G also serves to connect pipes F with supply pipe E, thereby furnishing the same pressure throughout all tubes for first forty pounds. When the first forty pounds are attained the stop cock on top of cistern, C, is shut and the pressure continued till forty pounds more are attained when stop cock at F is shut off. This process is continued to last column, which column is forty-five feet high. H, outlets for gauges requiring to be tested.

BUFFALO, March 1, 1874.

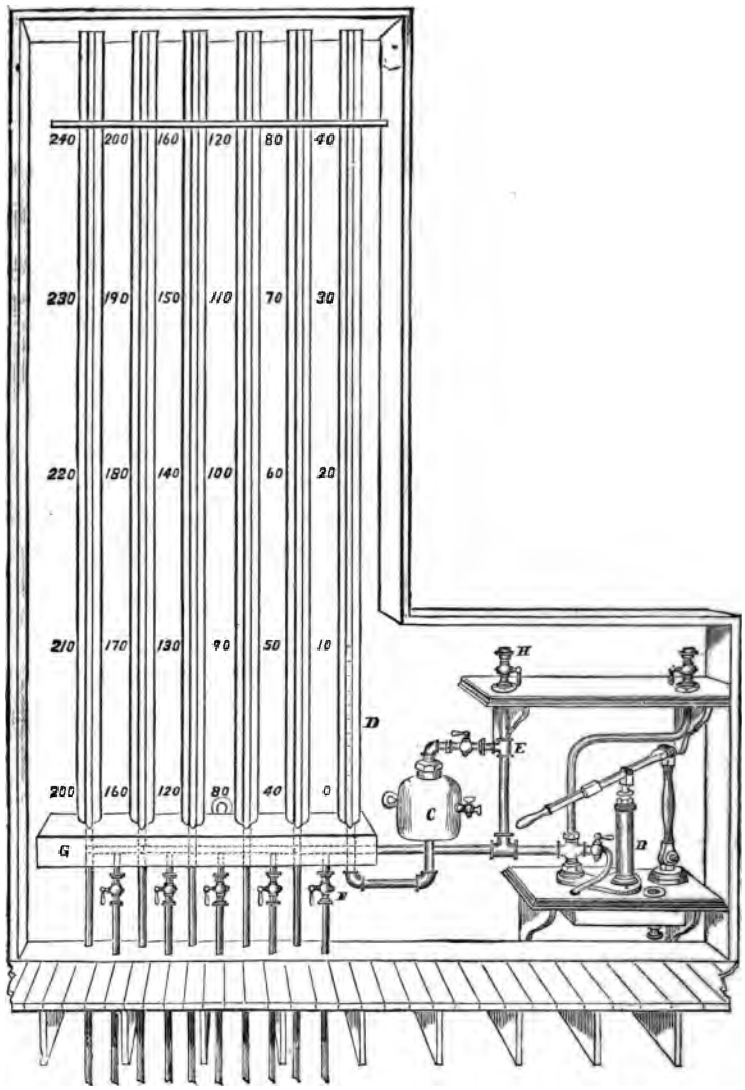
To the Committee of Master Mechanics on the best plan for testing Pressure Gauges:

GENTLEMEN—Your circular to our firm asking our experience and process of testing steam gauges at hand.

Although considering the mercury column that represents one pound per square inch to 2.04 inches height of mercury, is the standard for pressures, yet we do not depend *entirely* upon that for

Figure No. 8.

R. C. BLAKE'S MERCURY COLUMN.



perfect tests, we using in connection with a mercury column the following device:

We have a plunger attached to a force pump, working free, without friction, to that we attach a lever like a scale beam; all resting on a "V," or knife edges, and perfectly balanced by counter weights.

On the outer end of the lever we attach a rod to receive the weights, similar to a scale, which are uniform in weight to a dram.

In addition to this we attach to the end of the lever a hand movement like a gauge, which indicates the movement of the beam. In working the test water is forced under the plunger by the pump until the lever is raised off the seat and the indicator is moved to the proper point—this point is worked on the dial of the gauge. In our plan every pound weight applied works ten pounds. Another weight is applied and raised to the same position and continued until the number of pounds pressure to the square inch required is reached. The diameter of plunger, length of lever, and fulcrum must correspond to get the weight or pressure per square inch, and in every test it will always be accurate for each weight applied.

This machine, in connection with the mercury column, we use for regulating test gauges, and has the opinion of scientific men as to its accuracy.

We find but slight variation from tests by our mercury column and the above process, and only then in cases of impurities of the tube or variation of the temperature of the air.

Yours very truly,

THE BUFFALO STEAM GAGUE CO.,

RAY, MARVIN & HAM.

In conclusion, your Committee recommend that all steam gauges in use should be tested at least once in two months, and a record kept of the same. The best instrument for that purpose is a mercury column. If that luxury can not be indulged in, a very good substitute will be found in the steelyard testing apparatus, made by the New York Steam Gauge Co., or a similar apparatus; and if the ordinary test gauge and pump is adhered to—and every important railroad repair shop should have one of these appliances—then we recommend that the test gauge be sent once in a year, at least, to the maker for adjustment and correction.

We have endeavored to point out the good and bad qualities of

the safety valves and pressure guages in general use, without fear or favor, and with an eye single to the benefit of the great interest which this Association represents. If we have succeeded in awakening an interest in a matter too much neglected we will have accomplished our purpose.

Respectfully submitted,

CHAS. R. PEDDLE, *St. L., V., T. H. & Indiana*
W. E. RAY, *Toledo, Wabash & Western,*
S. KEELER, *Flint & Pere Marquette,*
} *Committee.*

On motion, the report was received.

Mr. ROBINSON, Great Western Railroad—Mr. President and gentlemen, being a member of the Supervisory Committee I have learned, in the course of the business, that there is a large number of reports to come before the Association and that those reports are rather extensive, and we shall probably find before we get through that they are a little more extended than most of us care for, still we must listen to them because there is no other means of thinning them down, with the exception of doing so in our own brains; and from the action of the Supervisory Committee I am quite sure that they will find it necessary to urge upon the Convention an extra session and for that reason I rise to propose that this session shall be as early as possible in the course of our business, and I ask to offer this resolution:

Resolved, In view of the importance of the subject of the Mechanical Laboratory, and the length of the report and papers of the Committee on that subject, that a special session of the Convention be held for its consideration this afternoon from 3.30 P. M. to 6 P. M., in the club room of the Sherman House.

Mr. ROBINSON, Great Western Railroad—It is a wet day, but I do not think our members will object to the day because other days might be finer, and as we are none of us too tired I think this afternoon would be a very good time to select for this session. I therefore take great pleasure in making the proposition.

THE PRESIDENT—You have heard the resolution offered by Mr. Robinson; are you ready for its adoption? It is impossible to meet in this hall this afternoon after two o'clock, and the proprietors of the Sherman House have tendered us the use of the club room, which will seat quite a number.

On motion, the resolution offered by Mr. Robinson was adopted.

THE PRESIDENT—When we adjourn, then, we adjourn to meet at half-past three in the club room of the Sherman House. I hope every member will be present. The next business in order is the discussion on the report which you have just heard read.

Mr. Coleman Sellers, of Philadelphia—Mr. President, the report just read is one of great interest to me. It treats of a subject that I have had under consideration for many years. There are two or three points to which it alluded about which I should like to make one or two suggestions. In the first place the present kind of safety valves that it seems to recommend, those patented valves and lock-up valves, which they say open with a loud noise or explosion. There has been a great deal of complaint made by owners of horses who have had them badly frightened by them. Mr. Tillman, the inventor of the valve, told me a short time ago that he had been experimenting upon the means of stopping the noise, and he found that, by putting a perforated plate over the top of the valve, and having the perforations of sufficient size to allow the steam to escape readily—exactly the same that you have over a pepper box—the difficulty was entirely obviated, that it escaped into its chamber and then came out freely with the operation of the safety valve which was not interfered with at all, and that there is no explosive noise. In regard to pressure gauges, which the report speaks of, the rusting of the springs and the use of nickel to obviate that difficulty, I would like to caution the members about the use of nickel plate as a preventative of rust. In all composition of metals, whether it be silver, or gold, or anything else, by the electrical process the metal goes down into the base heavily or softly. Some metals may be softened by burnishing; the harder metals can not be. Nickel is a very hard metal, and there is a free communication from the atmosphere through this crystalline metal into the metal below, and in very many cases where metal has been so coated the metal below is found to rust almost as freely as if it had not been plated. There is a patent—I don't remember who the patentee is—for the union of wrought iron and cast iron by the process of casting, by nickel plating the wrought iron and then running the cast iron upon it. Some time ago, having occasion to cast some tubes in a large caster for rolling-mill purposes, I proposed to try this. The tube was carefully filed all over, and thoroughly nickel plated. It was placed in the mold to have the metal run over it, and in less than twenty-four hours in the damp sand it rusted just as badly as if it had never been coated with nickel at all. The experiment was tried, some time ago, in regard to plating cutlery, and a large establishment in New England manufactured some very beautiful table cutlery, nickel plated, and the whole of that table cutlery rusted in the stores, so that they took it back themselves and refused to put it upon the market. I mention this fact as a caution against trusting to a crystalline metal that can not be rubbed down or burnished.

Mr. Towne, Northern Pacific Railroad—Mr. President, I would inquire on on the subject of safety valves for any evidence of the rusting of the Anderson valve. We have them on all the Northern Pacific engines, and I have never discovered anything of the kind. My experience, however, has been with the

Richardson valve, and I have always been rather inclined to favor that in preference to any other. The Anderson valve has been used on the Northern Pacific, and so far I have not found any trouble with it. It relieves the pressure very freely, very much more so than the Richardson valve, and I have failed yet to find any difficulty with them or any rusting of the spring.

Mr. C. R. PEDDLE, St. Louis, Vandalia & Terre Haute Railroad—Mr. President, I have examined quite a number of these valves in the course of these investigations, and I find that this rusting does take place, not only rusting, but the limestone water corrodes on the leaves of the spring, and interferes with its action, and I find it is almost impossible to get the rust off after a long time of use; but with the valve itself there is no trouble. The valve, I believe, generally has a cast iron seat and a brass back, and I do not think there is any trouble about the seat, but with the spring there is trouble. With regard to the action of the Anderson valve, and all those plain seated valves, we made an experiment which is a severe test to the valve ordinarily. When that safety valve goes off the engineer or fireman use every means to reduce the pressure; and in the experiment we tried we forced the fire and put the blower on and kept it on with a good fire inside the fire box, so that it was a very severe test. We found in this one case I refer to, that it would require an opening fifteen-sixteenths of an inch in diameter to pass the steam that would be made in an ordinary boiler, and we considered, with that as a basis, that it would equal about seven-tenths of a square inch; and any valve that would not raise seven-tenths of a square inch we did not consider safe. The only valve that did answer that purpose was the Richardson valve, which exceeded it—I think it was nine-tenths. The experiment was with one valve only, and that was an old one which had been in use for some time, and there was no particular care taken to prepare it for the purpose. I think it was a very fair experiment. I never knew the pressure yet to increase over the pressure at which the valve was set, and I do not know of any other valve but what will do that. I do not know of any plain seated valve but what the pressure will require you to decrease your steam some ten or fifteen pounds below the pressure rates.

Mr. ROBINSON, Great Western Railway—Mr. President, I would like to state that I am very much pleased to hear what Mr. Coleman Sellers has told us about the covering of the Richardson valve. That, I think, has come to be a most important question. I believe that the Richardson valve, as it now exists, without this covering is not only a nuisance but it is a disgrace to Master Mechanics; but with that improvement it may be all that is claimed for it. I speak of this improvement because I have met with ladies who have expressed themselves as being half frightened to death by that Richardson valve, and because of the number of vehicles and wagons that have been destroyed by horses having been frightened. I think

this is quite sufficient a cause for us to make some improvement in this direction, and therefore it is with very great pleasure that I have listened to these remarks; and I hope it will be regarded in such a way that all Master Mechanics having that valve in use will take due notice of the fact. I was reading about the Abyssinian war while riding on a railroad, and afterward I think I must have been dreaming about it because I was suddenly awakened at the time. The day was warm and the night was warm, and there was a freight train passing the window, and suddenly this valve went off, close by, and I thought I was killed. On another occasion an old lady in a sleeping car was woke up in the same way, and she screamed right out in the car. Now such noises are a disgrace, and any thing that scares people certainly is not right. It is our duty to comfort people in our vocation and try to make railways what they are designed to be, a comfort and an aid to progress. The Committee, I do not think, have very specially mentioned a valve we have in use on the Great Western Railway. I do not say much for that valve—no more than I think it is worthy the attention of those people who have not adopted any particular kind. It consists of two columns with a spring between the two, a spring being attached to a lever on the top of the two columns. This valve is in use on a large number of railways in Europe. I have brought a tracing of it as it is in use for the purpose of bringing it before the Master Mechanics who choose to take notice of it. It has been said that this valve is patented; I do not think it is in America at least. It therefore is free for the use of anybody who considers it worthy of their attention. I may say, that as far as it has been tried on the Great Western Railway, it has all the advantages claimed for the Richardson valve, besides I do not think I have ever noticed a boiler increase in its pressure over one and a half pounds, and certainly not over the two pounds of the pressure indicated in consequence of having any kind of lock-down arrangement in the valve itself. This valve is so sensitive that it does not allow the steam to exceed a pound and a half over the stipulated quantity; it also allows all the superabundant steam to escape, and we find it working very economically. It costs little or nothing at all for repairs, I think I may safely say. The valve may run ten years and want nothing done to it. If you have fifty or a hundred locomotives you probably may have to replace one spring. The spring is not exposed to any amount of steam, as it lays below the escape of the valves, and is therefore in a position where it has free action and is in sight of the driver where he can always see its condition; and what is more, the driver can screw down the valves or place more steam in the boiler. That is allowed in consequence of the arrangement of the lever, which is so peculiar that if he either lifts it up or bears it down it allows the steam to escape in the same way, just as much one way as the other.

This tracing is here for the use of the Convention, and will be left for that purpose.

Mr. PEDDLE, St. Louis, Vandalia & Terre Haute Railroad—I would ask Mr. Robinson if the tracing gives the shape and diameter of the seat?

Mr. ROBINSON, Great Western Railroad—It does. It gives all the particulars.

Mr. PEDDLE, St. Louis, Vandalia & Terre Haute Railroad—I can not see any advantage that that valve would have over any other plain seated valve. A plain seated valve, working with a lever, will increase the steam from eight to ten pounds per inch before it would relieve an increased pressure. I would ask Mr. Robinson, in the case of the pound and a half increase of pressure he refers to, whether the fire had been forced or not?

Mr. ROBINSON, Great Western Railroad—Whether it is any advantage or not I do not say, but I say in our experience that it has been sufficiently successful to have the advantage that I claim for it; and when we tried it we tried it both in the ordinary working of the engine and also by urging the fire. It was tried in connection with the Richardson valve and several other smaller valves of different construction. I do not bring this forward to urge it, but simply as a small addition to our stock of information.

Mr. PEDDLE, St. Louis, Vandalia & Terre Haute Railroad—I simply referred to the Richardson valve on its merits. If, as it has been stated here, it is a nuisance, and if Mr. Sellers is correct in his theory, I think we have got a good means of preventing that nuisance of a sudden explosion.

Mr. FARIES, Atchinson, Topeka & Santa Fe Railroad—Mr. President, I have been experimenting especially with safety valves for the last two years, and I found it impossible to make the Richardson safety valve work as I wanted it to, and one objection was this great noise that has been spoken of here, and the next objection was that I could not regulate the pressure as I wished to do. For instance: I wanted the lock-up valve to blow off a certain number of pounds, one hundred and thirty or one hundred and twenty-five, or whatever might be practicable, so that the engineer might not block the back valve. I only opened the down valve, and in order to increase the pressure between the two valves, one I set seven pounds heavier than the other; through this my forman got up a new valve, entirely different from that, which increased the annular flange and set that in the seat. That was down level with the top of the dome, so that the corner of one is just about one-sixteenth of an inch below the other, and by increasing that annular flange you can get any area that you want out of a two and one-fourth hole to relieve the boiler. It will never gain a particle. I would like to have some of these gentlemen try that. There is no patent on it; and I have adopted this plan, which I find works very well. I put a case right over the valve, on the forward dome, which answers to about what Mr. Seller spoke of. It goes all over that opening on top so as to

avoid this noise and makes a very soft sound, but does not do away with it entirely. That valve I arrange so that it carries one hundred and thirty-two pounds pressure, the ordinary pressure being one hundred and twenty-five pounds on the back valve when it raises. I failed to fetch a little sketch of the valve which I intended to bring here, but I can make one in a very few minutes. It is different from any thing that I have ever seen or read of. I see no objection to having the valve relieve to that pressure. There is another very good thing about it, and that is that it does not increase one particle with the blower on, and you can't make it increase. We have tried that thoroughly with heavy fire. That is because the valve raises so high when it goes up, the orifice being so large. It also saves fuel and water by holding the required pressure within a very few pounds of the blowing point.

Mr. W. S. Hudson, Rogers Locomotive Works—Mr. President, I perfectly agree with Mr. Robinson with regard to the popping valve being a nuisance. To me it is a complete nuisance. Though it startles me I can not say that I am afraid of being killed with it. I think it ought to be avoided, and with the information already derived, and about to be developed here, I think we shall find a perfect substitute, and thus avoid frightening old women and horses with the noise. We have heard patent mentioned. The Richardson valve is a patent valve, and perhaps that is not the worse of it. There is another patent in existence, I am told, that covers the principle of the Richardson patent, called the Nailer patent. The Nailer was an English patent, and patented in this country by Ashcroft, of Boston, and consequently there are two in existence covering the same thing. Now you, gentlemen, that have paid for the Richardson valve perhaps may have to pay somebody else one of these days; I don't know how that may be, but I merely mention the fact that such is the case, as I have every reason to believe. With regard to the valve that Mr. Robinson brings a tracing of, I can say that those valves are very generally used in Europe. I was over there last summer and I saw numbers of them, and from standing beside the locomotives I experienced no annoyance at all from their blowing off. Their action was very mild, and in my inquiries in relation to them I found they were perfectly satisfactory.

Mr. Robinson, Great Western Railroad—Mr. President, in order that Mr. Peddle may not think that my remarks were in any way personal, I would like before the Convention to say that I consider the Committees' report as very satisfactory. I do not think, as far as I heard it read, that there was any thing at all claiming any interest or approaching or looking to any interest or favoritism whatever, and I would like to have that thoroughly understood—that I think the report is very satisfactory in that respect. I spoke of it in a way that I should have done if there had

been no report here at all. I simply spoke of it in connection with the subject which had been brought up.

Mr. HUDSON, Rogers Locomotive Works—Mr. President, I may state, I think, further than that with regard to the Richardson valve, that it is patented in Europe, and while I was there last summer I called upon Mr. Hold who is the manager of the Hawthorne Locomotive Works, at Newcastle, and he told me that they were about having a suit for an infringement of the Richardson patent. In his investigations of the subject he had discovered that there was a patent granted some years before to Byer, I think, of the firm of Byer, Peacock & Co., Locomotive Builders, that covered precisely the same ground. Whether the suit has come off yet I am not able to say.

Mr. FORNEY, Railroad Gazette—I believe, if I understand the construction of the Richardson valve correctly, that its chief merit consists in the peculiar form of curve or groove, which is turned under the valve, and a corresponding one on the seat. I would like to ask members whether they have made any practical experiments in regard to the merit of those two curves or grooves. It is explained, I believe, to have a certain kind of reactionary effect upon the valve, and is thus thought to keep it up longer than it otherwise would if the seat were plain. The explanation is not satisfactory to me without some experiment demonstrating that fact. I will also add my testimony to that of Mr. Hudson and Mr. Robinson in regard to the great nuisance which the Richardson valve is. It goes off with a report enough to scare anybody, and if Mr. Robinson had not already done so well I should like to say a word in behalf of the ladies in this respect. Regarding the curves or grooves in the valve, I should like to know whether any gentleman has had any experience regarding its action. I think there was some reference made to it in the report, but I did not catch it.

Mr. ELLIOTT, Ohio & Mississippi Railroad—In answer to Mr. Forney, I would state I tried plain seated valves with perhaps three-sixteenths of an inch space, arranged exactly as the Richardson valve, and it was raised at the same pressure and going up a good deal higher, perhaps ten or twelve pounds higher, than the Richardson valve would under the same circumstances, and remained up as the engine cooled off, and continued to indicate on the gauge perhaps twelve pounds below the point that it raised at in the first place. Any experiments in that way will show that the Richardson valve will raise higher and relieve the boiler quicker. I can not account for that part of it—why it should come down quicker with the same strain on the top—but that it does this in practice I know. You take a common mitre valve and put a Richardson spring on top of it, and your pressure will run down perhaps eight or ten pounds below the point it went off at, and in using a Richardson valve it would perhaps not go more than two or three pounds—I never had them go more than three.

Mr. FORNEY, Railroad Gazette—I want to ask if the tops of the valves in both cases are of the same diameter?

Mr. ELLIOTT, Ohio & Mississippi Railroad—No; the tops of the valves are not of the same diameter. Mr. Peddle's experiments go exactly to prove that it did not make any difference in increasing the size beyond the bearing of the mitre.

Mr. FORNEY, Railroad Gazette—It seems to me that in the experiment that Mr. Elliott has made, unless the tops of the valves are of the same diameter in both cases, the result would not give a true test of the condition under which it works.

Mr. ELLIOTT, Ohio & Mississippi Railroad—I tried that, too, and then reduced it, but it made but little difference—the available steam would still run up. I know the Richardson valve will not vary as much as any other common seated valve. There is another point—this nuisance in the Richardson valve. When it is properly adjusted, as it is intended to be, there is no necessity for so much of this popping. Two of the Richardson valves ought to be applied to locomotives to make them safe. In one of them the first valve that goes off should be regulated by a set screw on the cross bar of the valve. You can regulate that so it will go off as soft as you please, and then set the pop valve five, seven, or ten pounds above that, and if the engineer and fireman will attend to their duty they never will pop, unless it is at some stop they are not expecting to make; but without doing that, if you allow that pop valve to go off every time it reaches the popping point, then you have your "pop" all the time; but by making some arrangement, merely allowing the valve to raise perhaps one thirty-second of an inch, it goes off perfectly soft.

Mr. PEDDLE, St. Louis, Vandalia & Terre Haute Railroad—The Committee did not think it necessary, in the first place, to investigate the matter of pops in their investigation of valves. They selected what they called the best valve, and so stated; but what the best coverings are, and how expensive they are, is another matter altogether. But in regard to the manner of the action of the valve, all I can say is, that in the ordinary plain seated valve there is no obstruction to the escape of steam into the atmosphere. The moment it passes the opening it is dissipated, and the pressure falls. There is nothing to prevent the escape of the steam in the Richardson valve into the outside rim. The steam strikes that rim and is confined more or less, and that throws the steam down in the groove below and makes a reaction, and the steam is turned up and escapes. I think the whole merit of the valve is in those grooves. The steam that is confined exerts a pressure to lift the valve, and the fact is that it does lift it. I have not found any plain seated valve that comes anywhere near it. I think in the plain seated valve the diameter must be largely increased. With a small valve you must have something more than a plain seat to retain the pressure to lift the

valve to the proper height. In regard to experiments with valves that Mr. Faries made, I tried some experiments which I thought indicated that it was superior to the Richardson valve. It did not make a loud explosion or pop, and we thought it answered a very good purpose; but when we came to investigate it and put it to a severe test, it was of no value. I think Mr. Sanborn will tell you some results of the valve also, for he has tried them on the other end of our road. He thought they were superior to the Richardson valve, but I think when the thing is nicely tested it will be found to be a mistake. I for one should be very willing to have this Committee or some other committee continued for another year to test this thing further.

Mr. Hudson, Rogers Locomotive Works—There is another feature in regard to these direct safety valves held down with springs that, I think, has not been mentioned here—that is the length of the spring. Suppose you put two or three of the springs ordinarily used one above the other, and test them. The question is, what effect that would have on the blowing off upon the amount of lift of the valve? It appears to me that would materially affect it, and I notice that the springs usually used on what is called the Ramsbottom valve are longer than what we are in the habit of using here. There is a length, undoubtedly, which is better than any other—that is, that will not cause the pressure to increase beyond reasonable limits. Suppose we take the Richardson valve and reduce the length of the spring a half of what it is ordinarily used, what would be the effect? Undoubtedly, it would materially interfere with its action. Therefore, there is some length better than any other. The question is, what is that length?

Mr. Elliott, Ohio & Mississippi Railroad—I would like to make an inquiry of Mr. Forney in regard to the shape of the Richardson valve. I would say that I believe, with an outside opening, in the opening through the seat of the valve, is *the* opening that must be regulated in relation to where the steam finally passes down, and by changing that a very little the action of the Richardson valve is altered. I think *that* has more to do with it than the *shape* of this opening. You have got to make that very fine to make it work just like an outside valve, passing down, as it were, and covering the other side of the valve.

Mr. Ellis, Philadelphia & Reading Railroad—I wish to make a few remarks in regard to a valve patented by A. J. Prescott, which was spoken of by the Committee, and with which I am very familiar. We are using fourteen of them on the Catawissa branch of the Philadelphia & Reading Railroad. We have also used the Richardson valve and the Cole & Taylor valve. The trouble we found with the Richardson and the Cole & Taylor valves was that they would allow too much steam to escape after they had been in operation for a short time. At one time we had occasion to grind the Richard valve; it was leaking badly, and after grinding it and firing up the engine and getting steam again we found that the valve lost

about thirty pounds of steam. We screwed it down to admit it to open at one hundred and twenty pounds. It blew down to ninety before closing again. We found then it was necessary to screw the valve down tight, and run by the one valve, in order not to lose so much steam but what we could pull the train with the engine. The trouble with the Cole & Taylor valve is also in leaking. The small valve was continually leaking, and it would charge the large valve and would make the valve pop sometimes at ninety, sometimes at one hundred, and sometimes at one hundred and ten pounds. We have about fourteen of the Prescott valves in use on this branch of our road. The majority of them were put on in 1871, some in 1872, and we have had occasion to grind only two of them since they were put into service, and they raise and lower by the loss of from one and a half to five pounds of steam, and they have given better satisfaction than any other valve I have had experience with.

Mr. Ellis here produced and exhibited a drawing of the valve to the Convention.

THE PRESIDENT—Gentlemen, the hour has arrived for the adjournment of this session; according to a vote of Convention we are to meet at 3½ o'clock P. M. at the club room of the Sherman House. Is there any more discussion to be had upon this subject?

Mr. ROBINSON, Great Western Railroad—I move that the discussion on this subject be now closed.

The motion was adopted, and the Convention adjourned until 3½ o'clock P. M.

EXTRA SESSION, OPENED AT 3.30 P. M.

THE PRESIDENT—The business called for this afternoon is the report of the Committee on Mechanical Laboratory. That report is in the hands of the Secretary who will read it.

Mr. ROBINSON, Great Western Railroad—Mr. President, as the chairman of the Mechanical Laboratory Committee I would like to say a few words which will enable the members of the Convention to take better hold of this report as it is read. During the operation of compiling the report of the Commitee on Mechanical Laboratory, certain correspondence was had with Professor Thurston; such correspondence having been opened by our friend and associate member, Mr. Forney, and Professor Thurston wrote to myself as chairman of the Committee, and it has transpired since our arriving at the Convention that Professor Thurston has made certain arrangements, through his influence with the Stevens Institute, which in some measure fore-

stalls all that the Committee has been getting at. They have with Professor Thurston made arrangements for the establishment of a mechanical laboratory, almost exactly what we are after; but it is in their own hands to a certain extent now. Understanding that you will probably pay particular attention to the report of the Committee and the way it stands, we desire you to note the fact that we did not know at all and only learned what had been done since our arrival at the Convention. Professor Thurston also has written a paper which he promised to do some time ago, but I did not know that he had accomplished it until I arrived here, when I found that our Secretary had in his possession the paper promised. Now the paper, as it happens, covers a good deal of the ground that the Committee's report covers, and you will no doubt discover a similarity between the two papers; but as the subject is one of great importance it probably will not be out of place to have them both read in order that we may fully comprehend the subject in all its bearings. With these facts it is like having a marginal reference to what you are going to read, and you will note them probably better in the order in which they come.

Report of Committee on Mechanical Laboratory.

To the American Railway Master Mechanics' Association:

GENTLEMEN—Your Committee, to whom was intrusted the consideration of the propriety of establishing a Mechanical or Testing Laboratory, issued its circular in due course, containing the following questions:

1. Should such a laboratory comprise apparatus for the solution of mechanical questions only, or for chemical also?

2. What mechanical apparatus, in addition to a train dynamometer, do you consider should form a portion of the property of such a laboratory? Give list of instruments.

3. What chemical apparatus do you consider should be possessed? Give list of same.

4. Should the laboratory be open at all times for reception of inquiries from any member of the Association, or only on special occasions for use of committees, on some certain form of application to be adopted?

5. In what city do you consider the establishment of the laboratory would render the greatest benefit to members of the Association generally?

GENERAL REMARKS ON REPLIES RECEIVED.

Although it is presumed that each member received a copy of these questions, only a small number of replies have been returned.

We are, however, inclined to regard this scantiness of answers as in no way arising from want of interest in such an important subject, but rather as a consequence of its novelty and the absence of any previous experience in respect to it. It is nevertheless very apparent, both from the *fewness* of the answers and their contents, that as a general rule the subject is one with which our members have had very little opportunity of becoming practically acquainted, a fact in which your Committee, in common with yourselves, can not fail to see cause for regret, and the present system of locomotive superintendence in this country so entirely absorbs the time and thought of Master Mechanics to the exclusion of the proper study of theoretical subjects that any early improvement is not very promising. We regard this state of our progress as scientific railway men as the best proof, not only of the *propriety* but of the great *necessity*, for some substitute similar to that under consideration to supply us with that kind of theoretical and experimental information needing careful research to which neither our leisure or opportunity are equal.

APPARATUS FOR LABORATORY.

Of those members who have sent answers all recommend that the laboratory should include apparatus for the solution of chemical as well as mechanical questions that occur in our practice; and, as far as your Committee can judge by the aid of the answers received, the apparatus to commence with should consist of such contrivances as shall determine any question coming under our department of railway economy and management, the following list being compiled from answers received together with what occurs to your Committee as proper and necessary:

1. Adjustable model valve motion.
2. Machine to test tensile, torsional, and compressive strength of metals.
3. Machine to test friction of metals.
4. Machine to test lubricating value of oils, etc.
5. Steam indicator with full diagram apparatus.
6. Most approved speed or revolution counter.
7. Pirometer for testing high boiler temperatures.
8. Thermometer with long range.

9. Vacuum gauge for use in locomotive smoke boxes.
10. Mercurial column for testing steam gauges.
11. Registering dynamometer for obtaining train resistances.
12. Microscope for examination of metals.
13. Means of testing caloric value of different classes of coal and principles of their most economical combustion.
14. Means of testing various qualities of water used.
15. Means of testing acids in tallow under high temperature.
16. Means of testing incrustation compounds and discovering their injurious ingredients when any.
17. Means of testing composition of specimen of boiler scale, etc.

NOTHING YET PURCHASED.

Page 192 of printed report of Proceedings of last Convention, will remind our members of the resolution adopted last year voting the sum of $500 from the Boston donation for the immediate acquirement of certain instruments for the laboratory. In respect to this resolution your Committee beg to report that they have deemed it prudent to postpone the purchase of any instruments until such time as the laboratory should be satisfactorily organized with proper arrangements for the reception and safe keeping of its property. Referring to the dynamometer it is proper here to mention that an instrument of this description has been very kindly presented and accepted by the Committee on behalf of the Convention, from Messrs. Prosser & Son, of New York, which is now on the platform for examination. It is constructed on the principle of compression of an oil, the pressure being indicated by an ordinary gauge. While this is a very useful instrument and apparently an improvement upon those constructed with springs, especially for purposes of weighing heavy loads, your Committee are of the opinion that if a dynamometer could be constructed in such a way as to be correctly self-registering it would be much more useful and reliable for the purpose of obtaining exact train resistances; for these reasons, while we recommend that the thanks of the Convention be conveyed to Messrs. Prosser & Son for their thoughtful donation, we include another similar instrument of a self-registering construction on the recommended list for the laboratory.

ORGANIZATION OF LABORATORY.

In reference to the organization of the laboratory, eight of the members who have replied to the questions recommend that it should be open at all times for the reception of questions, while five think regular stated intervals would be sufficient. Three recommend that the laboratory should be under the control of a special committee, to whom inquiries should be addressed, and one that it should be in charge of a curator on duty at all times, but under the control and instruction of a special committee. Your Committee are inclined to recommend a system embodying all that is valuable in these suggestions, namely: that if established, the laboratory should be accessible at all times by members of a standing committee, or by any member of the Association possessing a suitable card or written authority from the chairman or secretary of such committee, the laboratory to be in charge of a paid investigating engineer or curator, who shall at all times be in a position to attend and give service whenever called upon by duly authorized members; but no expensive or lengthened series of experiments to be undertaken except by resolution of the standing Laboratory Committee who will be responsible for all transactions of the laboratory, and furnish a report of all experiments made with results obtained to this Convention each year, together with a statement of expenditure, etc. The standing committee to be chosen by ballot, if necessary in open Convention, and to consist of five members of the Association, three at least of whom must have been regular members, and two *either associate* or *regular* members for at least one year before they shall be eligible to serve on this committee; two members of the standing committee to go out of office each year, but to be eligible for re-election. The title of all the property of the laboratory to be vested in a board of three trustees, consisting of the President *ex-officio* of the Association, and the presidents *ex-officio* of two of the most important railways, controlling not less than five hundred miles of road, to be elected by the Supervisory Committee. Any vacancy in such board to be filled up from time to time by the Board itself, subject to the approval of the Supervisory Committee of the Association.

LOCATION OF LABORATORY.

Your Committee do not feel themselves competent to give any decided recommendation as to the locality in which the laboratory should be established, as the number of answers elicited are insufficient to govern a decision; for this reason it is suggested that the question of locality shall be settled by vote in open Convention. Seven of the members who have replied mention New York as the most convenient city for this purpose, two mention Cincinnati, two Philadelphia, and one Chicago.

In connection with this part of the subject we have great pleasure in drawing the attention of the Convention to the very courteous and considerate action taken by our associate member Professor Thurston, of the Stevens Institute of Technology, or School of Mechanical Engineering, of Hoboken, New Jersey, in behalf of this undertaking. Some time ago our associate member, Mr. Forney, drew the special attention of Professor Thurston to the subject of our laboratory and its special requirements, with what result is probably already well known to most of our members in consequence of the publication of the matter in the *Railroad Gazette* of 14th March, 1874, a copy of which we affix below:

A MECHANICAL LABORATORY.

The following letter from Professor Thurston to the trustees of the Stevens Institute of Technology, and their reply thereto, need no explanation, excepting the statement that one or two other associations have entertained the idea of establishing a laboratory devoted to experimental research. The subject is more fully discussed on our editorial page:

DEPARTMENT OF MECHANICAL ENGINEERING,
STEVENS INSTITUTE OF TECHNOLOGY,
HOBOKEN, N. J., Jan. 30, 1874.

To the Trustees of the Institute—I have recently been called upon by gentlemen who are identified with important railroad interests, and who desired to discuss the advisability and the feasibility of a plan, already well matured, for the establishment of a department to be devoted especially to experimental investigations having a direct and practical bearing upon questions arising in the course of regular business.

A Laboratory for Technical Research, or a "Testing Laboratory" as it was denominated, it was stated, if properly organized, well equipped and effectively operated, could be made of exceptional value in the direct advancement of science, as well as in the promotion of purely practical interests.

The officers of our important lines of railroad, it was said, desired frequently to obtain dynamometric determinations of the resistance of trains and of the efficiency of locomotives; to learn with precision the strength and the various other hardly less important characteristics of materials which it was proposed to use in construction, and to ascertain the value of fuels and of lubricating materials.

Iron and steel makers are equally desirous of obtaining reliable and thoroughly accurate knowledge of the chemical constitution of their products and of their physical structure and properties, and such knowledge of the relations existing between these two sets of qualities as can only be secured by careful comparison of the result of skillful and systematic investigation.

The manufacturers of machinery and constructors generally are seriously in need of a recognized authority to which they may send the materials purchased by them, with confidence that their qualities shall be carefully determined and their value ascertained, and that the deductions from experimental examination shall be intelligently made, uninfluenced by any private interest.

Those members of the engineering profession who are engaged in general practice were said to constitute still another class of business men to which such an institution would lend valuable aid, and, in fact, every business would derive directly or indirectly great advantage from its establishment.

Were the foundation of this proposed laboratory to be shown practicable, it was thought that all would assist, and that the three classes just named would consider themselves justified in uniting to contribute to its creation and support; that business interest and a liberal policy would combine to secure its establishment on such a basis as would insure every facility for the investigation of problems arising daily in practical work in the systematic and thoroughly scientific and effective manner proposed.

It was considered that this laboratory, devoted to technical research and for the practical application of science in matters of business, should be under the charge of some scientific institution of acknowedged high character, in order that the perfect reliability of its work should be secured. It should be conveniently located in order that all of those who should aid in its establishment should find it readily accessible.

It should be supplied with the most delicate instruments, the most

powerful testing machines of all kinds, and a full supply of the best forms of dynamometric apparatus to engineers.

It should have conveniently near a corps of scientific men, familiar with the practice of engineering, whose opinion could at any time be asked in matters with which they might be most familiar.

The best collections of physical and chemical apparatus should be within reach of its officers, in order that they might, in the hands of those directly responsible for them, be brought into use whenever work in progress should render special researches in pure science advisable.

The laboratory should be provided with well trained and educated experimenters, capable of making satisfactorily any series of investigations that might be called for.

It was urged that these requisites could probably be best secured by the establishment of the proposed mechanical laboratory in connection with this Institute.

Its central location, its special adaptation in plan and methods of instruction as a school of mechanical engineering, its extensive collections and their exceptional character, the completeness of its organizations and its thorough adaptation in all respects to this kind of work seemed to indicate this as the best possible location for such a new department as that proposed.

It was thought that should the trustees consider it advisable to accept such an addition to their responsibilities, and to grant the space needed, and also to guarantee a hearty co-operation, there would be no difficulty in securing from business men to be benefited by it a sufficient amount of capital to purchase a complete outfit and probably to provide such an endowment as should insure its support, without in any way taxing the resources of the college.

Should the plan succeed, it was thought that a moderate income might also be obtained by assessing the actual cost of special examinations upon those for whom they might be made, which should provide for a continual increase of facilities by additions to its stock of apparatus and by the improvement of its *personnel*.

This matter has appeared to me an extremely important one, and I have therefore no hesitation in placing it before you and asking its careful consideration.

I have consented without hesitation, in the event of your favorable action, to aid as far as lies in my power in the organization and operation of such a laboratory, and have promised, should it become necessary, to assume the responsibility of its direction, and to endeavor to secure such an administration as should compensate its founders for their expenditure of capital, and the Institute for the tax which its support may incidentally bring upon it, and such as should

lend to the business interests of the country more efficient aid than they have been accustomed to receive from purely scientific work.

I believe that such a plan as that here laid before us would give to this country an institution such as has never yet been organized, and one whose value will prove beyond estimation. The accumulation of facts, the valuable application of science and the directly practical bearing of the work which may be done would, in a comparatively short time, be productive of richer results than have been attained in constructive science during many years past.

It would do most effectively that work which has hitherto been too much neglected, the application of scientific knowledge to familiar work and matters of business. It would do much to close up the space which so separated the man of business from the man of science, and would lead to a far more perfect system of mutual aid than has yet existed.

An institution like this can do no nobler work than that which, by assisting the improvement of technical methods and by the application of science to improvements in practical construction, aids in the development of the natural resources of our country, stimulates the growth, in extent and perfection, of its most important industries, and contributes in a thousand ways to the welfare of the people.

Very respectfully,
R. H. THURSTON,
Professor of Mechanical Engineering.

REPLY FROM THE TRUSTEES OF THE STEVENS INSTITUTE.

Prof. R. H. Thurston:

SIR—The trustees have to acknowledge the receipt of your favor of January 30, and have given it careful consideration.

They are so favorably impressed with the proposed establishment, in connection with the Stevens Institute of Technology, of an adjunct "Laboratory for Technical Research," or "Testing Laboratory," as you denominate it, that they gladly give the plan their cordial approval, and will render every assistance possible in its formation and maintenance.

Under proper restrictions they will be pleased to assume the responsibility of its government and safekeeping.

The trustees will accord all necessary space when not required by the Institute, whether within the present buildings or upon the grounds. They would grant the use of all facilities for investigation possessed by the Institute, only stipulating that the work of the college itself have precedence unless directed by them.

They would assist in organization and would gladly permit the faculty of the college to aid, as far as they may have the will and the

power, and would also accept such responsibility as may in propriety and of necessity fall upon them.

They would consider the adjunct department as, in all but its maintenance, a part of the Institute, and as such entitled to their protection and claiming their hearty support.

Whatever they could properly do, without in any way sacrificing the interests of the Institute, they would do with pleasure.

It should not be forgotten that the Stevens Institute of Technology was established as a special school of mechanical engineering, and as such has a well-understood policy and well-defined aim.

To the accomplishment of this work all of these facilities, supplied by its founder must be studiously directed, and the trustees do not, therefore, feel themselves at liberty to direct any portion of its income to the maintenance of even an institution so valuable as an adjunct to the college, as well as so important in its relations to industrial progress, as that proposed, and can not therefore promise to afford direct pecuniary aid.

Such facilities as are possessed by the Institute would be freely placed at the service of the managers of the proposed laboratory.

As business men we recognize fully the importance of bringing into as close relations as possible the science and industrial knowledge of the country, and we understand well the effectiveness with which the workers in the two fields may aid each other.

In establishing an "institution of learning," as directed by the founder of the Stevens Institute of Technology, they felt that its success in the field of labor chosen would become an important element in securing this corporation of science and labor, and of theory and practice, by giving to the world a class of men who should combine as effectively as possible these two important elements of successful training.

They already see proof of the correctness of their views, and they recognize in the proposed plan a means of rendering the work of the college still more effective.

They anticipate that the establishment of such an auxilliary would aid by bringing the work already in progress more fully before those who are best qualified to aid in making it more successful.

They see that good work in the direction indicated would add to the reputation of the Institute, and would assist in extending that reputation by securing the widest publication of the results of work done here.

Yours, etc.,

W. W. SHIPPEN,
S. B. DOD.

FEBRUARY 2, 1874.

From this correspondence it would appear that, through the influence of Professor Thurston, the trustees of the Stevens Institute are prepared to co-operate with us in the establishment and maintenance of such a testing laboratory as we require, on certain proper conditions governing its non-interference with policy and aims of the founder of the Institute. Your Committee feel that this is an offer which, for scientific value, consideration, and opportuneness, is not likely soon to occur again; and should the Convention decide upon New York City as the most convenient locality for rendering the greatest benefit from the laboratory to the greatest number of members, your Committee recommend the plan suggested in connection with the Stevens Institute as worthy of your serious and favorable consideration.

FINANCIAL OR WAYS AND MEANS.

The very newness of this undertaking, without any previous experience for guidance, renders it difficult for your Committee to give any recommendation as to the best method or plan of providing for the cost and maintenance of the proposed laboratory; and although last to be noticed this is a feature in the subject requiring the most careful consideration.

Should the Convention decide upon the immediate establishment of the laboratory, it should be prepared to provide a sum for instruments and apparatus of probably about five thousand dollars, more or less, according to the liberality of the spirit or nature of the requirements; but until the feeling of the Convention in regard to the offer of the Stevens Institute is known, and the exact nature of that offer determined, any estimate of cost of such a laboratory with suitable apartments can only be problematical.

The most feasible plan of meeting the first cost and future maintenance of the laboratory that occurs to your Committee, would be to obtain the co-operation of the presidents of all the railroads in the country, all being directly or indirectly benefited by the greater ecconomy that should follow from the prudent research of such an institution, and arrange with them for the levying of the expenditure over all railroads, pro rata, in accordance with the number of locomotives possessed or owned by each road. The tax on the shareholders

by such a plan would be merely nominal when spread over so large a territory. It would of course be unfair for such an expense to be borne by those roads only whose Master Mechanics are members of the Association, inasmuch as all railroads would be benefited even as they now are by the result of the mental toil of the Association through the medium of its reports—a fact which it is hoped will sooner or later be acknowledged by all railroad managers in their subscription to the expenses of obtaining such information, evén if they are unwilling for their Master Mechanics to assist by personal attendance. This, like other parts of the subject already mentioned, will be the better of free discussion among the members, in order that the standing committee, if appointed, may be informed of the exact sense of the Convention in regard to it.

QUESTIONS TO BE VOTED UPON.

As the basis of this report rests on six important decisons requiring the vote of the Convention, in order to save time, your Committee recommend that, in the event of its report being accepted, a vote as early as practicable be taken to decide the following points:

1. Shall a mechanical or testing laboratory be established in connection with the Association, having in view completeness and permanency?

2. Shall it be on the broad principles including the requirements of all the three classes mentioned in Professor Thurston's address to the trustees of the Stevens Institute, or only for the requirements of the mechanical departments of railroads?

3. In what city shall it be located?

4. If New York be selected, shall the offer from the Stevens Institute be accepted?

5. What pro rata principle shall we recommend to our companies for raising the fund for the purchase of the laboratory, and what plan for providing a sustenance fund to maintain the same?

6. Which members shall form the standing committee of five, to go out of office as stipulated, two each year?

In conclusion your Committee would remark that, during the Convention of last year, mention was made of some advantages to be

gained by having the laboratory fitted up in a car built suitably for the purpose, but so many objections presented themselves against such an arrangement that it has not been considered worth any further consideration at the present time.

Respectfully submitted,

W. A. ROBINSON, *G. W. R. of Canada,*
R. WELLS, *Jeffersonville, Madison & Indianapolis,*
JAS. M. BOON, *Pittsburg, Ft. Wayne & Chicago,*
N. E. CHAPMAN, *Cleveland & Pittsburg,*
H. M. BRITTON, *Cincinnati & Whitewater Valley,*
} *Committee.*

P. S.—Since completing the above report your Committee have received a paper from Professor Thurston of the Stevens Institute appertaining to this subject, and in consequence of its value in this connection beg to recommend that it be read and accepted as an appendix to this report.

W. A. ROBINSON,
For Committee.

On the Necessity for a "Laboratory for Technical Research" and on the Work of a Mechanical Laboratory.

INTRODUCTORY.

There are few men of any considerable practical experience in engineering who have not felt the great need of some well established and reliable authority to which they could apply for special information, either purely scientific or more strictly professional, bearing upon unfamiliar details of their work.

Probably every man who has grown up in daily contact with any branch of mechanical industry has seen hundreds and often thousands of dollars expended in the effort to obtain such information, and has seen the result accomplished, and the information, valuable as it was to many besides those who acquired it, remaining unpublished. The world at large is left as ignorant as before.

Repetition of the work by others has followed, and a similar expenditure of money has produced the same limited result, where one thousand dollars properly expended in securing the desired knowledge would suffice were the results properly communicated to the profession. Ten thousand or twenty thousand dollars may be expended by as many independent experimenters, each ignorant of the

other's work, and, after all, the hundreds of others who might have been benefited receive no assistance.

In many other cases experiments have been carried on, and large sums of money expended upon them without the slightest really new and valuable information being gained, either because the experimenters were unaccustomed to such work, and had but a vague knowledge of the real object to be attained, and still less knowledge of the proper method of obtaining it, or because of their unfamiliarity with the best methods of investigation, or in consequence of their ignorance of what had been already discovered and published by others.

It often happens, also, that a long course of experiments or a most tedious, elaborate, and expensive investigation is comparatively barren of results, in consequence of some apparently slight neglect which would not have occurred had the investigator been accustomed to such accurate work as is required.

Again, it has very frequently happened that engineers have remained for many years in ignorance of the real nature of some familiar phenomenon, or of some important principle, simply because its complete investigation required a comparison of experiments, made in the chemical or the physical laboratory, with the work of the mechanic in order to enable the subject to be intelligently studied in all its relations. The mechanical properties of materials, the effect of temperature upon the metals, the incrustation and corrosion of steam boilers, the value of lubricants, the heating power of fuels, and many other subjects, require for their full investigation the highest talent of the chemist, and of the physicist, as well as of the engineer.

The serious necessity of some great establishment which should be solely devoted to the work of investigation of such scientific and professional problems as are daily being presented to the engineer and the mechanic, in the progress of regular work, was forcibly impressed upon the mind of the writer when—then but a boy amusing himself in the workshop and drawing-room—he found himself unable to obtain accurate information upon even the most important subject involved in the design of the steam engine, or in the proportions of its details, and especially relative to those circumstances

which determine the quality of the materials used. The size of a piston rod, the thickness of a cylinder head, the proportions of a crank pin, were usually determined in nearly every shop, by no rules based upon careful investigation of the strength of the material, but were settled by "rule of thumb." The economical value of high steam and of expansion, the influences of piston speed, the laws governing the deposition of the salts held in solution in spring water or in salt water, the effect of surface condensation on the efficiency of the engine and upon the durability of the boiler, are all subjects in regard to which engineers held widely discordant opinions. The real effect of heat and cold upon materials was uncertain, and the laws governing the resistance of metals to blows, it was asserted, were involved in mystery.

When, in later years, he was intrusted with sometimes important work, more light was the reward of painstaking investigation, but it came slowly and was most unsatisfactory from its meagerness.

Experience in the management as well as design of engines and machinery at sea and on shore, revealed still more fully a great want of information in the most important branches of engineering work. We are getting on more rapidly to-day, but still too slowly.

Abroad some valuable work has been done—far more than in the United States, although something has been done here—our knowledge of the strength of materials upon the research of General Morin, of Tregold, Hodgkinson, Fairbairn, and Barlow, of Chevandier, and Westhiem, and of Vicat. Kilkaldy, Styffe, and Bauschinger have made the latest and most valuable contributions from foreign sources.

In this country a committee of the Franklin Institute, and Captain Rodman and Major Wade of the Army, Chief Engineer W. H. Shock of the Naval Engineer Corps, and a few others, have done good work, while Commander Beardslee, United States Navy, has recently added important facts to those previously acquired. The experiments of Clark in England, of Bauschinger on the Continent, and of Forney in the United States, have thrown some light on the distribution of steam in locomotives.

The labors of Trisca, of Morin, and of Coutomb on the laws and facts of friction, are the basis of our knowledge on that subject.

Our own Professor Johnson gave us an immense amount of information relative to the values and characteristics of American coals, and Baron Von Weber has given us important knowledge relating to the permanent way from experiments on European roads. Thus we find that some valuable work has been done in every line or research, which has become the standard that guides us in practical applications.

In nearly every case we shall find, on investigation, that the standard which conservatism insists upon our accepting as a guide in our work has been some time in existence, and that it is based upon experiments with materials which were quite different from those now in our markets, and that it was made when methods now perhaps obsolete were considered satisfactory. The world moved in practical research, is inclined to progress unstimulated.

In every field of labor we therefore meet with unexplored fields, and find ourselves daily at loss to determine the best method of doing our work. The best work which has yet been done in the most important branches of research has usually been of such a broad character, and has demanded the expenditure of so much time and money, that it has of necessity been done by governments or by wealthy corporate bodies.

Abroad we have in the French "Conservatore des Arts et Metiers" and in the laboratories of great technical schools of Europe, establishments where may be found men competent to do good work, and who are assisted by the pecuniary aid of their governments. It then happens that we owe very much to them.

In this country the same system which gives us political freedom operates against the successful prosecution of such work under the patronage of government. In matters of pure science, as in the work of the Smithsonian Institute, in that of the coast survey, and the occasional astronomical or geological expeditions which are carried out at public cost, the difficulties are not so serious. But investigations which have a directly practical bearing are liable to fall into the hands of those who are not thoroughly well prepared for the work.

It seems very certain that a really successful and permanently useful institution, devoted to investigation, must be partially if not

entirely sustained by private individuals legally responsible, and well known as qualified for their work.

METHODS AND INVESTIGATIONS.

The method of operation in the prosecution of any investigation may be detailed in a few words.

The investigator must first know definitely what phenomenon it is proposed to investigate. A vague desire to know more of any given subject is by no means sufficient to justify entering upon a work which may be found to be indefinite in its extent and infinite in its ramifications. As a rule, the more completely the work may be narrowed down the better. It must necessarily be ultimately resolved into one or more questions which may be stated with precision before any probably intelligent and remunerative work can be commenced. For example: To determine the effect of cold upon rails and machinery, which has been so often attempted and which still remains, to a considerable extent, an unsolved problem, we may find ourselves compelled to resolve this question into several, as, for example:

1. What is the effect of change of temperature upon the strength of pure iron?
2. What upon iron containing carbon, *i. e.* steel?
3. What upon iron containing carbon mechanically combined?
4. What upon iron containing sulphur chemically combined?
5. What upon iron containing phosphorus?
6. What upon iron containing silicon?
7. What upon iron containing cinder?
8. What upon steel containing sulphur?
9. What upon steel containing phosphorus?
10. What upon steel containing silicon?
11. What upon metal containing mixtures of these substances in the various proportions frequently met with?
12. What is the effect of change of temperature upon the ductility of all these metals?

And when we speak of the effect of low temperature we must not forget that it may have, and in fact does have, an effect in at least two ways.

It will affect the resisting power of a material not only by the change of molecular force, which is due to the change of the relative distances of the moleculars, but also by the simple fact of change of density itself.

Having determined all of these several simple effects, it remains to collect them and to so group the results that the great law underlying their action may be detected, and then the often exceedingly difficult task arises of expressing that law mathematically, or in some other way, which may make the work practically useful.

It is evident that this problem can only be solved by the combination of the intelligent efforts of the chemist and the physicist as well as of the mechanic.

Thus our simplest questions may, upon examination, be found to comprehend complex, and after difficult, problems, and may require for their solution the highest talent of not merely one man, but of a number of specialists, all of whose labors may be required to secure a satisfactory solution.

After deciding precisely what is to be learned, the next step is usually to ascertain how much has already been done of the work thus determined and limited. This usually requires a careful examination of the records of previous professional work extending far back into earlier times, and it frequently happens that a vast amount of valuable information may be gleaned, and the work immensely shortened, by studying the results already made public by native and foreign experimenters.

Much of the finest and most practically valuable work of their kind which has been yet accomplished will be found described in French and German engineering works and periodicals. The long standard works of Morin and of others already mentioned are illustrations.

Next, after the labor of examining and collating earlier researches, comes the planning of the new investigation proposed. This is as necessary a preliminary as the designing of an engine before work is commenced upon it in the shop. A thoroughly considered and well matured plan of operation will usually prevent any serious errors involving expenditure of money, or what is equally important the loss of valuable time.

The formation of a plan of operations requires a very definite knowledge of the character of the problem and an accurate understanding of the relative importance and probable bearing of the anticipated results, and a knowledge of the facilities available for the investigation. It presupposes a knowledge of the adaptation, range, accuracy, and reliability of the apparatus to be used, and not less important than all this is the knowledge of the extent to which assistance must be asked of, and how far aid may be expected from, special researches of a more purely scientific nature.

Skill in experimentation thus guided will then produce the best results attainable with the means at hand. The next requirement is a proper collation and registry of results, a matter in which there is opportunity to make useful a considerable degree of ingenuity and talent.

To make correct deductions from the records is the final task, and this is an exceedingly important matter. A lack of knowledge of the subject or of collateral facts may destroy the value of the whole work.

This work being properly done and the account of the research being properly written out, a contribution to knowledge will usually be found to have been secured which has a value to the public, and sometimes to individuals, far exceeding that of the time and the money expended in securing it.

Men of science have often devoted the best years of a life-time to the investigation of a single train of phenomena, seemingly insignificant in comparison with the great facts surrounding them, yet neither they nor the world think this is a wasteful expenditure of time. The value of acquired knowledge is never to be measured by the value of immediately apparent results or of evident applications, yet, in the course of the practice of the engineer and the mechanic, it rarely happens that such experimental work as he is compelled to take in hand does not bring an immediate and ample remuneration, while the ultimate benefit accruing is often immensely great in proportion to what is paid for it.

We usually find that we help ourselves by such work to a most satisfactory extent, and at the same time are enabled to give our

neighbors of our light without sacrifice, and to experience the gratification of benefiting the profession and the public.

LOCATING A MECHANICAL LABORATORY.

The location of such an establishment as would be well adapted to general work of the kind here contemplated, and to the prosecution of special investigation of a directly or indirectly practical character should be carefully selected.

The necessity of frequently calling for advice and assistance of both practical and scientific men, and the desirability of securing accessibility will prevent its satisfactory operation if it is not located so as to be within reach of a large proportion of those most interested in its establishment and maintenance.

The necessity which will frequently arise of making accessory investigations of a scientific character, in various branches of natural science, will dictate its establishment, probably, in connection with some conveniently situated and well established technical institution of learning, provided with well stocked laboratories, conducted by men capable of appreciating the importance of the work and of properly pursuing such investigations and who will take an interest in the subject.

The institution should have a character which is readily defined. Its magnitude is not so easily determined. It may be of very limited extent, and may yet do a vast amount of good; or it may become a vast establishment, employing a large corps of able men, making use of extensive collections of valuable apparatus and machinery, and making profitable use of larger capital than the French "Conservatore des Arts et Metiers," already alluded to, which has an annual income of nearly seven hundred thousand francs, five hundred thousand of which comes from the State. In a large and growing country like ours, peopled by the most active and enterprising of every race, the future of such an institution, if properly managed, would be whatever its managers and those whom they aid might choose to make it.

Its stock of apparatus would be determined, in character and extent, at first by the nature of the work most imperatively needed. It would probably comprise a set of machines for testing the strength

and other no less important qualities of the materials of construction, dynamometric apparatus, instruments for testing lubricants, steam engine indicator, calorimeters, pyrometers, and thermometers, and apparatus for determining the heating power of fuels. A mercurial gauge with the usual accessories for comparing standard gauges, standard weights and measures, instruments for determining specific gravity, and other well-known forms of experimental apparatus would be needed.

Special apparatus and instruments adapted to new methods of investigation and new fields of research would rapidly accumulate, as they might be constructed for special purposes or contributed from outside sources, and would ultimately form a collection of very great value. A small collection of machine tools would be needed for the purpose of preparing materials and of making or repairing apparatus.

THE PERSONNEL.

The personnel of this establishment would probably consist of a director who should be, if possible, familiar at once with the theory and practice of the profession of engineering, and who should also have as large a knowledge as possible of science, particularly in its bearing upon his work. He should have able assistants of similar qualifications, and should be able to appeal to men of science and practical men alike for advice, with confidence that it would be given and that it could be profited by. Good mechanics to take charge of tools, to aid in preparing apparatus, and to assist in manipulation, and some unskilled labor would complete the list.

Such an institution as has been here briefly described, doing the work which is most immediately required by the various branches of manufacturing industry and of engineering, would be of incalculable benefit to mankind. As remarked by the writer in addressing the trustees of the Stevens Institute of Technology on this subject, such an enterprise "would give to this country an institution such as has never yet been organized, and one whose value would prove beyond estimation. The accumulation of facts, the valuable application of science, and the directly practical bearing of the work which may be done, would in a comparatively short time be productive of richer results than have been attained in constructive

science during many previous years. It would do most effectively that work which has hitherto been too much neglected, the application of scientific knowledge to familiar work and to matters of business. It would do much to close up the space which so widely separates the man of business from the man of science, and would lead to a far more perfect system of mutual aid than has yet existed."

It would, by aiding the progress of improvement in our methods of work, and by the application of scientific knowledge in practical life, aid in the development of our material resources, lend a new impetus to the industrial enterprise of our people, and assist to an extent which can probably hardly be conceived in the promotion of our national prosperity.

A decade of such work as could and should be done, when such facilities are rendered available, may be expected to be more fruitful of practically useful results than a quarter of a century of unsystematic, desultory, and unorganized efforts, such as has hitherto been our only method of acquiring information.

THE STEVENS INSTITUTE OF TECHNOLOGY AND ITS LABORATORIES.

The convenient location of the Stevens Institute of Technology, its exceptionally complete collections, its special adaptation in consequence of its organization as a school of mechanical engineering, and by the training of its officers and employees to such work, has led gentlemen well known in connection with railroad work and with the iron and steel industries to ask whether it would be possible to induce its authorities to inaugurate such an institution as a part of its department of engineering.

The evident interest which the plan has awakened among all classes engaged in engineering and mechanical work induced the writer, who had long believed such a laboratory to be one of the necessities of the present time, to address the trustees upon the subject. This correspondence in which the case is stated by the writer, and in which the trustees acquiesce in the views presented with an interest and a promptness of action which exhibits a thorough appreciation of the importance of the subject, is appended, and will be read with interest by every one.

It is seen that the trustees of the Stevens Institute of Technology have consented to inaugurate a mechanical laboratory, and it is to be hoped that this germ, which is just now commencing its development, may grow into something as noble in itself and as grand in results as its most interested and enthusiastic friends can possibly have anticipated.

It is a pleasure to be able to announce also, that those who are most interested in the matter are taking prompt action in aid of the plan. This society of Master Mechanics has its standing committee, which is ready to do all that lies within its province, and it may be expected to give valuable aid and advice.

The American Society of Civil Engineers have taken similar action, and their committee stands ready to co-operate with other societies and with individuals, and to assist also by advice and active exertion in securing ample means for the inauguration of this important project.

Leading members of the iron and steel associations and of the press are taking an active interest in the subject, and the plan will be so thoroughly published that it must succeed if the advantages apparent are at all appreciated by those who are to be most directly assisted.

HOBOKEN, N. J., MAY 1, 1874.

Prof. R. H. Thurston, Stevens Institute of Technology:

SIR—The trustees, after a more thorough consideration of your letter of January 30th, referring to the necessity of a laboratory devoted to technical research, and especially designed to meet the necessities of the industrial interests of the country, have decided to assume the initiative and to endeavor to provide the nucleus of such an institution as that proposed in your letter just referred to. You are therefore authorized and requested to organize a MECHANICAL LABORATORY, as an adjunct to your department, and to assume the direction of its affairs.

You will take charge of such contributions as may be made by those interested in the creation of such an establishment, whether of apparatus, of machinery, or of capital, and account for them to the trustees. In accepting such contributions you will submit to

the trustees the proposed conditions of acceptance before completing any agreement with the contributors.

You will, in the expenditure of funds, in the erection of buildings, the purchase and establishment of apparatus and machinery, and in the employment of subordinates, use every precaution to secure the greatest economy and a full equivalent for funds so used. You will establish all necessary regulations for the successful operation of the new department, and will provide such a schedule of charges for work done for private parties as shall cover actual expenses, and give a margin of profit amounting to not less than twenty per cent. of such expense, which profit shall be charged to a capital account for the purpose of securing a gradual increase of the stock of apparatus, and the accumulation of a fund which may ultimately be used in the erection of buildings and in securing enlagred facilities for special researches.

In making regulations for the guidance of those having occasion to avail themselves of the facilities, which it is proposed to provide for the examination of materials and for research, you are desired to make provision, where possible, for a fair return upon their investments to those who may aid in the establishment of the laboratory.

You will make a report to the trustees in January of each year, in which you will state the amount and the character of work done during the previous year, the condition of the department, its growth and its wants.

You will be expected to render an account of receipts and expenditures semi-annually, January 1st and July 1st, and in the statement which shall accompany the annual report you will give an account of stock, and a statement in full of the value of all property held on laboratory account.

The trustees of the Stevens Institute will transfer to the director of the Mechanical Laboratory the following property, to be held and used for the benefit of the laboratory:

1 steam engine of four-horse power.

1 steam engine of fifteen-inch swing.

1 speed lathe.

1 power planing machine, five feet bed.

1 small hand planing machine.
1 universal milling machine.
1 upright drill.
1 emery grinder and wheels.
1 set taps and dies.
1 set reamers.
1 set Whitworth gauges.
1 lot miscellaneous tools, as per inventory to be submitted.
1 testing machine with autographic registry to break iron and steel of five-eighths inches diameter.
1 Emerson dynamometer.
1 Salleron dynamometer.
1 Woltmann mill for determining velocity of streams.
1 Baumgarten mill for determining velocity of streams.
1 wheel with dial for determining velocity of water.
1 pilot tube with dial for determining velocity of water.
1 anemometer.
2 Richards steam engine indicators.
1 MacNaught steam engine indicator.
2 spring balances, British measure.
1 spring balance, French measure.
1 blacksmith forge.

To the above list there will be appended some other apparatus, as yet unselected, the whole having an estimated value of $5,000. The boilers of the Institute will be allowed to furnish steam to drive the engines and tools.

The trustees will assume charge of permanent funds, and will endeavor to invest them properly. They will decide when it may be advisable to expend all or any portion thereof for the purpose of enlarging the field of usefulness of the institution for the benefit of which they may have accumulated.

You are authorized to make use of such available space within the buildings of the Institute as shall be necessary for the accommodation of the proposed laboratory, and to call upon the employees for such assistance as may be needed, whenever such aid may be rendered without interfering with their regular work, or their duties

to the officers of the Institute. It is presumed that such assistance will meet all requirements for several months at least.

Whenever it shall occur that a total subscription of sufficient amount to erect buildings shall have been received, the trustees will further appropriate to the use of the proposed mechanical laboratory a strip of land adjacent to the Stevens Institute of Technology, not exceeding two hundred feet in length and fifty feet in breadth, valued, at present prices, at not above $20,000, on which such buildings may be erected.

The total appropriation thus made is to be credited to the Institute as a shareholder for its amount $25,000. The trustees will also hold themselves in readiness to share the management of the laboratory with a board of trustees, of which the President of the Stevens Institute shall be *ex-officio* president, and on which board contributors shall have representation in proportion to the aid given; this transfer to take place whenever the majority of stock representing subscriptions shall vote it advisable.

Very respectfully,

(Signed by the Trustees.)

The President—Gentlemen, you have heard the report of your Committee with the papers prepared by Professor Thurston, the Committee recommending that they be added to the report. What action will you take upon it?

On motion, the report and papers were received.

The President—The next business in order is discussion of the report.

Mr. Robinson, Great Western Railroad—Mr. President, I would like to ask Mr. Forney or Mr. Coleman Sellers, who, I think, are probably better acquainted with Professor Thurston than any one in the room, whether they are aware of the exact position of our funds as a Master Mechanics' Association if we should appropriate any of our money, and place it in the hands of that Institute, how far would we have control of and how far be responsible for it if placed in the hands of the Stevens Institute in the manner proposed by Professor Thurston or the trustees of the institution? In that connection I might say that I understand by our President that we have some $3,500 on hand from the Boston donation which we could, if we saw fit, use for this purpose; and, as a member of the Convention, I would strongly advise the greatest caution in everything we do in regard to the expenditure of that money.

Mr. Forney, Railroad Gazette—Mr. President, I would state that I am acquainted with Professor Thurston and have known him for several years. I know him to be a gentleman of very great ability in his profession, and one who has had considerable practical experience and has been engaged at the Stevens Institute now for several years. I believe him to be entirely responsible for everything which he might undertake to do both so far as his personal integrity is concerned and his ability to manage anything of the kind submitted to him. I have every reason to believe that the Stevens Institute is entirely responsible for any money which may be intrusted to them. So far as the arrangement proposed by Professor Thurston is concerned, I have not conferred with him before reaching here in regard to it, nor have I seen the document which was read to this Association; and, therefore, I should not like to express any definite opinion in regard to the advisability of doing anything about it without a little more consideration and hearing a discussion from the members present. I agree with Mr. Robinson that any such thing should be acted upon with very great caution before we adopt any course.

Mr. Coleman Sellers, of Philadelphia—Mr. President, as my name is used by Mr. Robinson, I would state in reference to the Stevens Institute of Technology that it is probably the only institution in America devoted entirely to teaching mechanical engineering; that so far as that is concerned it would seem eminently fitting that it should have attached to it such a laboraty as is proposed by Professor Thurston. If the railroads of the country were to contribute a large sum of money toward founding this laboratory in connection with the Stevens Institute, there is no question but what Stevens Institute would be very largely benefited. It is now solely dependent upon the bequest of Mr. Alexander Stevens, who left about three quarters of a million dollars to be expended in this school. That has already been appropriated, and with the endowment of professors their own means are probably limited. If this thing is built at all it will have to be built by outside means I should judge. As in the case of Mr. Forney I never had read the proposition of the trustees and never knew about it though I have had letters from Professor Thurston in regard to it several times. I think that it is there stated that those persons who contribute shall be represented in its management, pro rata, to the amount of their contribution. It seems to me, then, that if the Master Mechanics' Association should induce the railroads of the country to invest a sum of money to be placed in that or any other institution it would hold to the Master Mechanics' Association the right to use it to the extent of their means. I do not think that such a laboratory can be started without a large sum of money is raised by all persons interested in the questions to be decided by it. Mr. Holley sometime ago thought the steel interest of the world hereafter was to be led with the chemists and not with the practical men; that up to a certain point practical men had ac-

complished a certain result and there stopped, and progress after that was entirely in the hands of scientific men. It is precisely the same in the higher mathematics. There is no question but what we have in the practical information of the whole of our own members an immense fund of information, but it is scattered. They are all working in different directions. The force of the institution is not concentrated, as it were, and it is eminently proper that in such a country as America there should be some place to which we could apply for that practical solution of questions as they come before us. This, as has been stated by Professor Thurston, can not be done by those who are unaccustomed to the mode of thought necessary for such investigations. These investigations can not be carried on blindly; they must be conducted by persons accustomed to the method of thought required in this study. Professor Thurston is one of those who probably promises better than any mechanical engineer who is acting as professor in the country to fulfill the requirements called for. I have the highest opinion of him as an engineer; and, without wishing to urge on this Association an acceptance or rejection of the proposition of the trustees, I think it is eminently fit that it should be considered with a great deal of deliberation; and the first step it seems to me in that direction is for this Association to find out how much money it could control for the purpose of carrying out such an idea.

Mr. Setchel, Little Miami Railroad—Mr. President, I desire to ask the Committee on Mechanical Laboratory and the Convention whether this is a paper upon which we can take any definite action. It is not signed by the trustees; and suppose we should accept it, what is there to bind them to the proposition that they have made?

Mr. Robinson, Great Western Railroad—It does not seem to me there is any particular difficulty, because if we take any action at all I think our action will be taken through a second special committee, either this one continued a year or a new committee, who would have the care of investigating further and making sure of all the points being covered, and that committee would certainly see that all necessary steps were taken to insure legality in all respects. So I would suggest that whatever is done be done through a carefully selected committee.

Mr. Wilson Eddy, Boston & Albany Railroad—Mr. President, if it is pertinent to the case I would like to ask how this money is proposed to be raised for this purpose; if we as individuals are expected to contribute to it, or if it is expected that it will come out of our respective roads? I, for one, if it is to come out of the society or out of us as individuals by contribution, should be opposed to the whole thing. I do not believe that it is our duty, it is not mine, when we look around and see how many of us there are that are liable to belong to the society only a year or two, and we see from year to year that our numbers change very essentially, some dropping

off and some coming in. I am inclined to the opinion that if we take the matter right home to ourselves or look at others, we shall see that very few of us will be benefited by it. For one, I do not feel that I should be benefited by it many years, nor those whom I am directly interested in coming after me. If we ask our respective companies to contribute to us, so that we can control apparatus for these various purposes, will not they tell us that they had rather we would use our education to determine a more economical way of hauling freight, or something of that kind, rather than to be spending our time and their money for something in the direction proposed. This is a question, it seems to me, that we better look to pretty closely. I generally calculate, whenever I take sides, that people shall know where I am from the very start; and, as I said before, if it is to come out of us individually by contribution or as an association, for one, I am opposed to it.

Mr. TOWNE, Northern Pacific Railroad—Mr. President, if I understand this matter in reference to the mechanical laboratory correctly, it is proposed to be self-sustaining entirely, and I do not understand how it can be conducted in any other way. Therefore, how it is to be self-sustaining is the question. If we are to contribute to the organization of a laboratory, or to the capital fund for the establishment of all this apparatus, the purchase of land for building and all that kind of thing, then, I understand, it is to come out of the members and not out of any railroad company. It is our own personal hash, as I understand it, and we are to receive any benefit that may hereafter come of it as individuals. I do not understand that any railroad company would be particularly benefited in themselves, except generally as, of course, the whole country at large is. The question to my mind is, how it can be made self-sustaining unless the grounds that the trustees propose to appropriate in the future, for the purpose of a building and machinery, be at once appropriated, and a building sufficiently large to commence some sort of manufacturing be erected, so as to make the institution self-sustaining from the beginning. Then there would be some inducement for us, as members of this Association, to contribute a capital fund for the purpose of starting it. If there is any one that understands the matter differently, I should like to hear from them.

Mr. ROBINSON, Great Western Railroad—Mr. President, until some other member is ready to speak, I would refer the last speaker to a paragraph on the ways and means from the report of the Committee. It should not be forgotten that we have made our report independent, and that this action of the Stevens Institute has, as it were, if I may use a homely phrase, given us a very respectable lift. We have been pushed on one notch further than we ever expected to have got by this time; and I must say when I saw what had been done by the Stevens Institute, that I was very much surprised in a delighted way. I was surprised to see other people taking such an interest in the same thing. What they have done gives the subject such a new face

that it seems to me we shall have to consider the matter some time further. I do not think there is one in this room who would go to his railroad company and place this subject before them in its present position. As we had it before us, it simply meant this—how the Master Mechanics, combining together, could supply themselves with the *modus operandi* of furnishing themselves with theoretical information which they at present could not obtain. There it stood, a simple question; and I do not think there is one of us in this room but what, if we take the right means, could go to our companies, if they are intelligent companies—if they are not, we do not care to have anything to do with them—but if they are intelligent railroad companies, then I think they would give sufficient money, which would probably take only a few cents per locomotive, to secure apparatus and instruments to be on call or ready for the use of any member of the Association. Had the thing remained in that state it would probably have amounted to only some fifty cents per locomotive, and is almost silly, I think, to talk about a company declining to give fifty cents per engine. One of the ordinary wipers in a shop will damage an engine more in five minutes than that. If the company should refuse to do that for me I would say, "Gentlemen, I am very sorry for you and I will pay it on your account." Suppose you take fifty cents per locomotive—as I understand, there is somewhere about twenty thousand in this country. I think every road ought to contribute that has sufficient capital to own a locomotive at least fifty cents per engine for the class of information to be derived in this manner, and for the economical use of that information. Fifty cents a locomotive would give us $10,000, and by putting $3,000 more to it, making $13,000; it would be a very handsome sum to do all we ever expect to be done. It would be our own property, subject to the will of this Association or to its special committee. Now, when you come to the new face put on by the action of the Stevens Institute, it is a different thing. I fancy, if I were to go to our railroad company and ask them to give me the same donation that I should have gone to them for before, and tell them I was going to hand it over to the Stevens Institute, I think they would wonder what in the world I was talking about. That is not the same thing at all. One would be very proper in connection with the railroad, the other is proper in connection with some institution. Railroad shareholders, as far as I know anything about them, have adopted this rule—that it is their business to provide a railroad and rolling stock, and to run that railroad, and to have nothing to do with any other business. Those railways that do that seem to be successful. Our line is so far bound down to that principle that they wont build even a house in an out-of-the-way place for a foreman or any one to live in, because it is not their business to buy or build real estate—so that I think they would put this question on that footing. That is the way I see the difficulty is going to come in. It is new to me, as it was only last night that the matter came before us. Our President and Supervisory Committee

read this report over, and we were a little surprised at the length and fullness of it, as well as the subject matter. I am, therefore, totally unprepared to say what we ought to do with it. I think all we can do is to ask what questions we can, and then defer any decision until we have had time to confer a little more about it. It may possibly be that we shall determine to leave it to the Committee for further inquiry for a year, or something of that kind; but I am certainly not, although chairman of the Committee, prepared to recommend you to make any fixed decision.

Mr. Coleman Sellers, of Philadelphia—Mr. President, in reference to the use to which this laboratory may be applied, I took the trouble some time ago to inquire of one of the leading railroads what method of investigation and questions suggested would be referred to this laboratory. I found that they were very loth to spend any money in the purchase of apparatus to be used by their employees for that purpose. Some of the employees had suggested the buying of some of these very things that are needed in these investigations. A few pieces of apparatus were purchased because they were deemed absolutely necessary; such, for instance, as steam indicators; but when it came to the question of microscopes, why, it was thought that would be more play than anything else, and it would not do. I then made inquiry as to how they expected to obtain the information they desired. They said it was done entirely through experts; that if a question came up in which it was necessary for them to arrive at a decision they did not wish to confine themselves to any particular person or set of persons to give them the necessary information, and they looked about the country for practical experts in that direction, and paid for the information that was obtained. That was a fair case. Properly fitted up laboratories exist all over the country, and to them these matters are referred. It seems to me that it would be very injudicious for this Association to act hastily in this matter. I do not think that to lay it by for one or two years would be at all out of the way, provided something was eventually done that would be of use. As Mr. Eddy has very justly said, there is no question but what the Society is a very evanescent one; it is one dependent upon people holding certain positions, and they remain active members so long as it is to their advantage to be mechanical engineers connected with railroads, but if they should leave that position in all probability their interest would be diverted from it. The Society exists totally different from such a society as we may say the Franklin Institute, which is a society having a location and building, and its members, of course, die off and others are added to it, but its vocation remains fixed. Such an institution can very well collect about itself a laboratory and apply its laboratory to the use of its members. But there seems to me a great many difficulties in the way of attaching a laboratory to an institution that is merely formed with men who come together because they are in a particular trade, and that is the position held by this Master Mechanics' Association.

I do not think that it would be a wise thing for the members of this Association to be precipitate in any action at all in regard to it.

Mr. EDDY, Boston & Albany Railroad—Mr. President, the last gentleman but one who had the floor said that we had had considerable of a boost, and had been pushed on quite a notch. I admit it, sir; and I rather turned my shoulder on it, thinking, perhaps, it would push us a little too hard. When anybody undertakes to push me pretty hard I generally calculate to see whether they are going to push me off a precipice or into some labyrinth or hole that I can not get out of. That is why I spoke as I did. As I said before, I do not believe that the gentlemen here who compose this Association, as a general thing, want to contribute funds for this. As far as I am concerned personally I care but little about it. I can do it or not. Perhaps, if it is thought best after discussing it fairly, I should turn in and do as well as the rest of them, but I shall oppose it for the present. As far as the railroad is concerned I agree with Mr. Sellers. It does not look to me, Mr. President, when a railroad company on the occasion of such a meeting as this refuses to pass us and our wives and daughters here, that they are going to contribute to such a fund as this, and the acquaintance that I have had for a good many years with railroads induces me to believe that we should be knocking at a door that would not open to us if we undertook to get funds at the present time for such a thing as this.

Mr. J. A. JACKMAN, Chicago, Alton & St. Louis Railroad—Mr. President, at first, I thought I would not say anything upon this subject; but, as it is under discussion, I will claim the attention of the Association for a very few remarks. A laboratory would be a very fine thing—I would like to have one in our own shops, and I suppose every Master Mechanic would like to have a laboratory connected with his shop, where he could go in and examine things himself, or with the assistance of those he might employ; but if this Association has a laboratory situated somewhere in New York, or at any point, of how much real benefit will it be to some of those persons who live at the extreme point away from the laboratory. True, they can send to this laboratory and ask questions. There are certain things that may be solved by those who have charge of it, but what is there that may be solved by it that is not already solved and tabulated statements made in regard to it? Let us examine for a moment. Suppose you want to test the strength of iron. I ask a person how much iron will hold, so far as its tensile strength is concerned, and we send to this laboratory and ask them to make the experiment, and they do so and send word back that it will hold so much. Now, is that experiment, made by this laboratory, of any more value than the tabulated statements that you can find in a dozen standard works that have tested the same thing as thoroughly as it could be tested in this laboratory? Then, suppose you want to try the strength of iron in another way, and you send to them to have it tried in that way. They send

back a statement of how much the iron will bear; well, that is all very well, but haven't we got all such things? Isn't it all down? Are there not men continually working at these investigations and continually publishing books, and don't we have the result of what those men do by buying their books and reading them? I have made it a point from year to year, as long as I have been engaged in the business, to test everything that I could test. For instance, I wanted to try the transverse strength of iron. I took certain pieces, and sometimes I have been to the expense of casting in the foundry a dozen or more pieces of cast iron, for the purpose of testing them; made them one foot long and one inch square, and got them just as perfect as I could, and then laid them upon supports and put on weights until they would break. So far as cast iron is concerned I have tested it in that way as accurately as I would weigh tea or sugar, or any other thing that I might be dealing in. Then I would take wrought iron and fashion it out the length that I wanted, and plane it as nice and as square as possible, then put it upon these points and put on weight until it got a permanent set, noting all the time how much it would bear before it took a permanent set, and how much it required to give it a permanent set, and how much it took to crush it or bear it down. Then I have tried all the different kinds of wood in that way, and I have tried iron by pulling it apart to test its tensile strength, and I have tried it with water and with steam and all those forces, just as far as I could go with the limited means that I have. I have made these tests and compared them with tabulated statements that I have found. My tests were not very accurate, probably, but in many cases they would agree very nearly with these tabulated statements. Although a laboratory of the kind proposed, if we could have one, would be the means of establishing certain things that we want to establish, and giving us the information about certain things that we want to have, but can we do this any more correctly or any better than it is already being done? Suppose, for instance, we should take up the subject of astronomy, and should say to the person who has charge of our laboratory, get the telescope, or get other instruments, in order to measure the distances of stars and make other astronomical investigations. Well, we could do a good deal in that way, and make some measurements and calculations that are made by other astronomers; but would we arrive at any more correct results than those others, and would we get any truer or better statements or descriptions than we can already get from standard books published in the country by men that have given the subject their utmost thought? That is what I want to get at. Of course, the mere fact of its costing us money is of very little consequence. I think that a great many railroads would contribute something, and not a few of them would contribute liberally, to something of this kind if they could be made to see that it was going to accomplish the objects that they wanted—if it could be made to appear to them that it was going to be of interest to them

in money matters—but if not it would be of no use to us or them. What we are laboring for is something that will pay. The great point, Mr. President, of a Master Mechanic or a Superintendent of Machinery upon a railway is success. If he takes hold of any road or occupies any place and becomes successful, and makes everything go well, he is useful and profitable; if he does not do that, he does not accomplish what is expected of him. It matters not whether he is successful by means of the laboratory or by other means, his great object is success. So far as the different kinds of water and fuel that are used in locomotives are concerned, we have examinations with tabulated statements, and those tabulated statements are just as reliable, probably, as any that we should get from a laboratory that was under our own direction. I very well agree with my friend, Mr. Sellers, that this subject will bear thinking of, and that it is not well to be hasty in regard to it. It may be, after we have given it sufficient thought and sufficient discussion, that we may conclude it is for our interest to raise this money and help establish this laboratory; but it will not do to act hastily in the matter. What I have said has been said just for the purpose of drawing out the views of the members present on this subject, and so far as they shall express themselves in regard to it, I hope they will say exactly what they think, and if they don't agree with me it is all right. My idea in regard to the matter is that, unless we should do something more than superhuman, we could not accomplish very much more than what is accomplished from year to year by those who do examine these subjects, and publish the result of their examinations so that the whole world can have the benefit of those results if they choose.

Mr. HUDSON, Rogers Locomotive Works—Mr. President, Mr. Jackman has made statements here that would very well justify us in inquiring why he was led to experiment at all, why he could not take the published statements and statistics in regard to the strength of iron, and not go to the trouble and expense of casting pieces of iron and hanging weights on them to break them. Why not take the tabulated statements already published on that subject? Why, the gentleman answers his own question by the simple fact that he wanted to ascertain the strength of some particular kind or piece of cast iron which was not like, perhaps, any other piece of cast iron. He might do the same thing with regard to some new kind of steel or other material which he could not find in tabulated statements. If everything was tabulated and remained the same yesterday, to-day, and forever, what is the use of our coming here to discuss these matters and to interchange our experience? If these things have been all done years ago, and are all recorded in these books that are authorities, why can't we take them? Now, gentlemen, I do not think there is any question with regard to the necessity of experiments being tried, and of the most reliable information that it is possible for us to get upon all these subjects. A great many people and a great

many large establishments provide themselves with means of testing their own manufactures and metals as to tension, tortion, compression, and every other quality. We all see that it pays them to do so, and it would pay the railroads to do it; but I have no hope they will see it in that light. Let us hope that they will contribute to pay the expense. If we do these things, we have got to tax ourselves; I am willing to be taxed to the extent any of you are for this purpose; I will contribute as far as any of you out of my own means. I will not ask the company that I represent to contribute a dollar, because I do not believe they will do it, and I presume many of you are in about the same position. They are willing to avail themselves of our efforts, and our investigations and expenditures, but they say "Because you are in our employ, the effort of your brain belongs to us." The railroad companies—the men who hold the dollars—take a good deal such a view of the case. I am sorry it is so, but so it is; therefore, I say we must depend upon ourselves to raise the means for carrying out these objects. That the objects are important there is no question at all; we ought to have the apparatus, and we ought to be enabled to solve the questions that may come up, and to solve them in a satisfactory manner.

Mr. FORNEY, Railroad Gazette—Mr. President, I move that the discussion be postponed and made a special order for twelve o'clock to-morrow noon.

Carried.

On motion, the Convention adjourned to nine o'clock A. M., Wednesday.

SECOND DAY'S PROCEEDINGS.

The Convention met at 9 o'clock, Wednesday morning, May 13th, President Britton in the chair.

THE PRESIDENT—The first thing in order is discussion on the report of the Committee on Boilers. That Committee wishes a paper prepared by Prof. Joseph G. Rogers to be read, and some experiments to be made by him prior to the discussion. I now have the pleasure of presenting to you Professor Rogers, of Madison, Indiana.

Professor Rogers then read the following paper, illustrating the subject as he proceeded with chemical experiments:

Paper of Joseph G. Rogers.

To the American Railway Master Mechanics' Association:

GENTLEMEN—In investigating the subject of steam boiler incrustation, it will be necessary first, to consider the chemical constitution of natural water, the source from which all scale-forming elements are derived.

Pure water consists of the two gases, hydrogen and oxygen in chemical combination. It holds nothing in solution or suspension; water as found in nature, however, is never chemically pure. By contact with the earth's surface and by percolation through its alluvium and rocks, more or less mineral matter is dissolved or carried away in suspension or mechanical mixture. Even the raindrop brings with it from the clouds a certain amount of adventitious gaseous matter acquired by absorption in its passing through the air. The accompanying table exhibits the constitution of a variety of waters.

It shows an extensive list of elements and a remarkable variety of relative proportions.

By reference to it, it will be observed that sea water contains 3½ per cent. of saline matter in solution, about 25,000 grains per gallon; that of the Dead Sea 16½ per cent. River and lake waters contain from 1 to 24 grains per gallon in solution, and a varying quantity in suspension, generally exceeding 10 grains; well and spring water hold but little in suspension, but in solution a quantity varying from 10 to 150 grains. The relatively greater proportion of salt in the sea is due to the fact that it has been, since the beginning, the great reservoir for all the waters that wash the earth, and that by constant evaporation the solution has become more and more concentrated, the pure water vapors going back to the clouds to fall again as rain and run into the sea loaded with new saline increments. Besides these mineral substances more or less vegetable matter is found derived from the same source. Certain gases are also present in a free state; oxygen, hydrogen, carbonic acid, nitrogen and sulphuric acid, the first three being always found in certain localities; the waters of wells are impregnated with nitric and nitrous acids. The forementioned substances are found in a great variety of combinations. The quantity and character of the mineral matter

TABLE OF ANALYSES OF NATURAL WATERS.

Nos. 1 *to* 6, *inclusive, show the ingredients in one American standard gallon* (*or* 58,372 *grains.*) *Nos.* 7, 8, *and* 9, *are in one pound Troy, and Nos.* 9 *and* 10 *in* 1000 *parts.*

	1	2	3	4	5	6	7	8	9	10
INGREDIENTS.	Schuyl-kill River	Croton River.	Charles River.	Spot Pond.	Long Pond.	Mystic Pond.	Saratoga C. Spring.	Seltzer Spring.	Sea Water Brit.Chan	Water of Dead Sea.
1 Chloride of Potassium	....	....	....	....	.0380	.1590	1.6256	.2685	.7660	traces.
2 Chloride of Sodium	.1470	.167	.1547	.3969	.0323	27.911	19.9690	12.9690	27.9590	78.650
3 Chloride of Ammonium	....	....	....	....	....	....	.0360	....	traces.	....
4 Chloride of Calcium	....	.372	.0420	....	.0308	.1544	....	....	....	29.220
5 Chloride of Magnesium	.0094	....	....	....	.0764	....	....	....	3.666	50.950
6 Chloride of Aluminum	....	.166	....	....	....	....	....	....	....	....
7 Bromide of Sodium	....	....	....	....	....	....	.1613	....	....	....
8 Bromide of Magnesium	....	....	....	....	....	....	....	....	.0290	7.950
9 Iodide of Sodium	....	....	....	....	....	....	.0046	....	traces.	....
10 Sulphate of Potash	....	....	....	....	....	....	.1379	.2978	....	....
11 Sulphate of Soda	....	.153	.3816	.2276	....	....	....	....	....	....
12 Sulphate of Lime	....	.235	.2624	....	....	1.2190	....	....	1.4060	traces.
13 Sulphate of Magnesia	.0570	....	....	....	.1020	1.9768	....	....	2.2960	....
14 Sulphate of Alumina	....	....	....	....	....	.4478	....	....	....	....
15 Nitrate of Magnesia	....	....	....	....	....	....	.1004	....	....	....
16 Phosphate of Lime	....	....	....	and iron.	....	....	....	.0007	....	....
17 Phosphate of Alumina	....	.832	.0973	.1081	....	.2810	....	.0020	....	....
18 Alumina	....	....	....	....	.0800	....	.0069	....	....	....
19 Silicic Acid	.0800	.077	traces.	traces.	.0300	.5559	.1112	.2265	....	....
20 Carbonate of Soda	....	....	....	....	....	....	.8261	4.6162	....	....
21 Carbonate of Baryta	....	....	....	....	....	....	....	.0014	....	....
22 Carbonate of Strontia	....	....	....	....	....	....	.0672	.0144	....	....
23 Carbonate of Lime	1.8720	2.131	.1610	.3722	.2380	.9894	5.8531	1.4004	.0330	....
24 Carbonate of Magnesia	.3510	.662	.0399	.1420	.0630	.1698	4.1155	1.5000	....	....
25 Carbonate of Manganese	....	traces.	....	....	....	....	.0202	....	....	....
26 Carbonate of Iron	....	....	....	....	....	....	.0173	....	....	....
27 Fluoride of Calcium	....	....	....	....	....	....	....	.0013	....	....
28 Salts of Soda with the Nitric and Organic Acids	1.6436	1.865	.5291	....	.5295	....	....	....	....	....
TOTAL	4.2600	6.660	1.6680	1.2468	1.2220	32.7671	34.7452	21.2982	35.255	165.770
Carbonic Acid Gas in cubic inches	.3879	17.418	.0464	38.79	10.719	10.313	in 100 114.	c. in 126.		

in any particular water depends entirely on the constitution of the earth, or rocks, over or through which it has passed, and upon the conditions of location, motion, and exposure to light, heat, and air which it has undergone. Upon this variety depends the variation in the adaptability of waters for use in steam boilers. On being evaporated the water escapes as a vapor, but the now volatile mineral matter contained in it remains as a residue. The deposit of this residue takes place as shown in the following experiment:

EXPERIMENT SHOWING MANNER OF SCALE FORMATION PER A RETORT.

We place equal parts of salinated solutions of carbonate of lime and sulphate of lime. The mixture represents artificially a very hard boiler water, we now apply heat and observe the results.

In the evaporation of any natural water, as ebullition goes on the contained free gases are driven off, since they are not soluble in hot water. As the presence of carbonic acid is necessary to the solution of the carbonate of lime, magnesia, and iron, these salts which are found in most waters are precipitated in a finely crystaline form, tenaciously adherent to whatever they fall upon. *Sulphate of Lime*, which is commonly present, is soluble in 400 parts of cold water, but scarcely at all in boiling water, therefore as the evaporation proceeds super-saturation occurs, and this salt is thrown down in a crystaline form possessing a still greater hardness and tendency to adhere than the carbonates. The other contained elements which are all more soluble than those mentioned, are precipitated in the same way by super-saturation, the most soluble being the last to fall. As the quantity of water is lessened, the *suspended* matter gradually subsides and agglutinates with the other deposits. In a steam boiler the deposit tends to take place in the same manner, but the constant supply of fresh water and the occasional emptying out of the salinated water prevents the precipitation of the more soluble salts, these are retained in solution. Practically it is found that the deposit from all kinds of boiler waters consist almost entirely of the carbonate of lime, magnesia and iron, and the sulphate of lime, scarcely more than five per cent. of other salts are found.

ANALYSES OF BOILER INCRUSTATIONS.

Number	Structure	Thickness	Sulphate of Lime	Carbonates of Lime and Magnesia	Oxide of Iron and Alumina	Silica	Organic	Water	Total
1	Comp. & Crystalline.	3-16 in.	74.07	23.97	0.08	0.65	Not Est.	1.14	99.91
2	" "	2-1 in.	71.37	*28.63	....	....	"	....	100.
3	" "	1-32 in.	62.86	31.57	0.92	2.60	"	1.28	99,23
4	" "	1-3 in.	53.05	*46.95	....	....	"	....	100.
5	" "	1-32 in.	46.83	*47.85	....	5.32	"	....	100.
6	" "	1-4 in.	30.80	58.10	1.08	7.75	"	2.44	100.17
7	" "	1-4 in.	86.13	*13.87	....	....	"	....	100.
8	" "	1-16 in.	82.10	15.60	*2.30	....	"	....	100.
9	Friable & Granular.	2 in.	4.95	88.86	1.03	2.07	"	0 63	97.54
10	" "	1¼ in.	0.88	96.03	0.36	0 62	1.96	0.15	100.

* Represents total amount of all the remaining elements.

By reference to the Table of Analyses of Incrustation it will be seen that in certain deposits the sulphate largely predominates; such are compact and very crystalline. In others the carbonates are more largely present; such are friable and granular or in a state of fine powder. The deposit under ordinary management gradually accumulates, becoming thicker and harder. It is sometimes as dense as porcelain and much tougher. Deposits containing silica, under the influence of high heat, are sometimes converted into absolute glass by the combination of the silica with the lime and clay.

In moving boilers where surface condensers are not used, a musty deposit of common salt is precipitated, but this incorporates only to a slight extent with the agglutinated incrustation of the before mentioned salts of lime. This is prevented practically by keeping the boiler water below the point of saturation by more or less constant blowing.

The evil effects of scale are due to the fact that it is relatively a

non-conductor of heat. Its conducting power, as compared with that of iron, is about 1 to 37.5.

The apparatus illustrating the relative conducting power of the two substances consists of a short brass tube into one end of which is screwed a short rod of iron, into the other a rod of very dense scale; the whole is suspended above a spirit lamp so as to distribute the heat from the central brass piece. In a small cavity at the end of each rod is placed a detonating powder, which explodes at one hundred and twelve degrees Fahrenheit. In a few moments that on the iron rod will explode; that on the scale rod will require a much longer time, as will be observed. It is readily demonstrated that a scale of one-sixteenth of an inch in thickness will require the extra expenditure of fifteen per cent. more fuel. This ratio increases as the scale grows thicker. The crust sometimes, when very dense and thick, will so interfere with the transmission of heat to water inside a boiler, that it is impossible to raise the required amount of steam by any amount of fuel that can be placed in the furnace. If a boiler be perfectly clean the contained water may be raised to any given temperature by heating the fire furnace a degree or two higher, but if any scale be present it will be necessary to heat it very much higher, in an increasing ratio, according to the thickness of the scale. To illustrate: To raise steam to a pressure of ninety pounds the water must be heated to a temperature of three hundred and twenty degrees Fahrenheit. If the boiler be clean this may be done by heating the fire surface to about three hundred and twenty-five degrees; but if half an inch of scale intervene between the iron and the water, such is its non-conduction that it will be necessary to raise the fire surface to a temperature of about seven hundred degrees, almost low red heat. Now the higher the temperature at which iron is kept the more rapidly it oxidizes and undergoes molecular change. At continued temperature above six hundred degrees it soon loses its fibrous nature and becomes granular and is more or less carbonized. In this condition it is brittle, and under high heat liable to bulge or even give way to the internal pressure upon it. Weakness of boilers thus produced predisposes them to explosions and makes necessary expensive repairs. To obviate these evils, namely: danger from explosion, expense of

repairs, loss of time and waste of fuel, very many methods have been devised having in view the prevention and removal of scale. For this purpose picking, scraping, chaining, etc., are generally resorted to periodically. Such is the toughness and tenacity, however, that mechanical force only succeeds in removing a portion of it, and is generally unsatisfactory, since, in addition, it is necessary to empty the boiler and allow it to get cool enough to enter, which, with the operation itself, requires a whole working day.

Various mechanical contrivances have been and now are used to intercept the precipitated saline matter from the supply water on its passage through the heating apparatus. They consist essentially of a series of obstructions to the flow of the water. This latter being heated to boiling by being intermingled with the exhaust steam in the heater, the carbonic acid is driven off and a precipitation of the carbonates take place as exhibited in the retort, the deposit accumulating on the shelves, straw, or other obstructions over which the water slowly flows. In this way large accumulations of the matter in suspension and of the precipitated carbonates are prevented from going into the boiler, and, being retained in the heater, may be removed very conveniently when opportunity is afforded. This plan, however, only partially remedies the difficulty since it is only the precipitated carbonates and the matter in suspension that is retained by this apparatus. The soluble salts all pass on to the boiler, and also a great portion of the earthy carbonates which can not be precipitated during the short passage through the heater. The scale in the boiler more slowly but as surely forms. Another variety of mechanical device for preventing scale is the sediment pan. This, of which there are many forms, consists essentially of a shallow vessel, which is placed at the bottom of the boiler, with the view of catching the precipitate and preventing its deposition on the inner surface of the shell. They are removed at intervals and cleaned. This plan succeeds in gathering much of the sediment, but much necessarially fastens itself to the boiler, and the scale, as before, continues to form.

It is impossible to make any mechanical contrivances completely efficacious; the great *desideratum*—perfect prevention—can not be attained by any mechanical means. To chemistry alone can we look

for a complete method. For a long time simple chemical agents were used, in an empirical way, with a certain success. Some of these and their *modus operandi* I will notice: Molasses, fruits, slops, vinegar, cane juice, and a variety of vegetable substances, containing more or less acetic acid, when placed in a boiler at regular intervals will remove and prevent the incrustation to a certain extent.

The acetic acid decomposes the carbonates, forming acetates, which are kept in solution and hence can not become increments of scale. The sulphate of lime and other salts are not affected by it, and from this the scale will gradually be formed; moreover the iron of the boiler being open to the attack of the free acid will be gradually corroded, and after a time rendered useless if not dangerous. This fact alone ought to forbid the use of these agents. Starchy matter, in the various shapes, of potatoes, corn, oil cake, etc., has been much used. These prevent scale only by enveloping the precipitates with gelatinous matter, which lessens their weight and prevents their agglutination into a solid moss.

Starch, as well as nearly all other organic matter, has a tendency to produce frothing of the water in the boiler, in which case the exact quantity present can not be determined by the gauge cocks. This is a source of great danger and ought to prevent the use of such agents.

Oak, hemlock, and other barks and woods are operative in the prevention of incrustations on account of the tannic acid which they contain. Various extracts, such as catechu, logwood, etc., rich in tannin, are also used. Tannic acid decomposes the carbonates, form ing tannates, which are insoluble; but their specific gravity being light they do not subside, but remain continually floating in the boiler currents; and, moreover, being amorphus they have no tendency whatever to agglutination and therefore do not incrustate on those surfaces with which they come in contact.

EXPERIMENT SHOWING ACTION OF TANNIN ON SCALE-FORMING WATER.

Into a solution of carbonate of lime, made by passing carbonic acid through lime water until it is clear or almost so, put a small quantity of tannin previously dissolved in distilled water. The resulting

precipitate is tannate of lime as above described. Carbonate of magnesia is decomposed in the same manner.

Into a solution of sulphate of lime, made by pouring water through a filter filled with plaster of paris, put another portion of tannin solution. No reaction occurs, this showing that the sulphate of lime is not decomposed by tannin, and will form a scale notwithstanding its presence.

The same objection holds against tannin, in its free state, as offered in the above-named agents, as does against free acetic acid; it *will attack the iron* of the boiler, though, as the tannate of iron is insoluble, the corrosion will not be as rapid as with the acetic acid, which forms a soluble acetate with iron. To prove that *tannic acid will corrode* metals, it is only necessary to put some of its solution into a solution of persulphate of iron, the resulting black precipitate is tannate of iron. The fixed alkalies are much used in the various forms of lye, ashes, sal-soda, caustic soda, potash, etc. These agents decompose the sulphate of lime, the resulting sulphate of soda or potash being retained in solution and the carbonate of lime precipitated.

EXPERIMENT SHOWING THE ACTION OF CARBONATE OF SODA.

Put a solution of carbonate of soda into this solution of sulphate of lime, and observe the precipitate of lime. The carbonates of lime and magnesia, held in solution by free carbonic acid, are precipitated by the appropriation of the acid to carbonates or bicarbonates of soda or potash; but, as with the sulphate of lime, the crystals being larger, do not form so refractory a scale as when precipitated by boiling alone; still, as these earthy carbonates form the major part of nearly all incrustations, this method, which fails to do more than merely modify their form and qualities without affording means for their voidance, deserves little attention. Ammonia and its carbonate have a precisely similar action, and are similarly objectionable. The alkalies have no corrosive action on the boiler; but, on the other hand, rather tend to prevent it by appropriating the free carbonic acid, which ordinarily combines with the insoluble crust of oxide of iron (iron rust) on the inner surface, forming a soluble carbonate which,

being constantly dissolved away from the iron, leaves a surface continually exposed to fresh action.

Muriate of ammonia is another means of obviation. This has its action only on the earthy carbonates. The resulting carbonate of ammonia being volatile passes off with the steam, and the chlorides of calcium and magnesium are retained in solution. This is a very efficient way of removing old scale, since the earthy carbonates constitute the greater portion of most incrustations. Its only objection is the ammoniacal odor in the steam. Petroleum has been highly recommended, but late developments in the oil regions of Pennsylvania lead me to conclude that it has been found to possess corrosive action. The *rationale* of its action is difficult to give, owing to its chemical complexity.

The foregoing are methods in which a single agent is depended upon. Many compounds have been devised with a view of overcoming all difficulties. Many such have been patented, and many more are sold as secret proprietary preparations. Tannin is the basis of most of them, generally in combination with various alkaline salts and some starch-bearing substance. These elements, some useful and some useless, I have found nearly always in a state of mere mechanical mixture, and not uniform in chemical constitution. They generally contain more or less free tannic acid, which is objectionable on account of the slow corrosive effect on the boiler, and an amount of insoluble vegetable matter which is liable to cause foaming. Besides these methods, in which chemical agents are put directly into the boiler, others have been devised in which the waters are depurated in tanks before entrance into the boiler. Clark's method consists of the admixture of lime simply. This precipitates the earthy carbonates by appropriation of the free carbonic acid which holds them in solution. The newly formed carbonate of lime, being insoluble without the presence of free acid, also falls; the supernatant water is drawn off for use; sulphate of lime and other salts remain untouched. This, in turn, might be removed by carbonate of soda—carbonate of lime being precipitated, and sulphate of soda being retained in solution. Another method, proposed by myself, consists essentially of the conversion of the earthy carbonates into soluble chlorides by hydrochloric acid, the

excess being neutralized by filtration through carbonate of baryta (witherite) in coarse powder. The soluble chloride of barium thus formed will decompose the sulphate of lime, the resulting chloride of calcium being very soluble, and the sulphate of baryta insoluble and very heavy. The latter subsides forming a deposit not easily disturbed.

This simple apparatus* will exhibit the action of this method. It consists, as you see, of an acid reservoir from which through a small siphon drops the acid. Another from which pours the hard water artificially represented by a mixture of sol-sulp-lime and carbonate of lime—the funnel contains a filter of carbonate of baryta. As the water pours through the reaction before mentioned takes place, and the water is fit for boiler use. This may be proven by testing it for the lime salts by the introduction of the carbonate of soda solution. As we see no precipitate form, therefore there is no carbonate or sulphate of lime. By this method the carbonates of lime and magnesia and the sulphate of lime, which constitute ninety-five per cent. of the scale-forming matter, are completely changed into very soluble chlorides, which will not form scale under any circumstances. Tannic or acetic acid, the excess being properly neutralized by carbonate of soda, may be also used for tank depuration. With the tannin insoluble tannates are precipitated; with the acetic acid the carbonates are converted into soluble acetates; the neutralizing alkali will decompose the sulphate of lime, producing soluble sulphate of soda and precipitating carbonate of lime.

Another method recommends itself for water stations of railways, on account of its cheapness and perfection when properly applied. The carbonate of soda or potash alone may be used, as it will precipitate all the lime and magnesia as carbonates. All these tank methods require supervision, and can not to any great extent influence the scale already formed; and, as the removal of this is as needful as its prevention, it is palpable that, for general application, that method is best which attains the complete removal as well as the prevention of scale by chemical means operating inside the boiler.

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* Professor Rogers demonstrated his method by an apparatus at the stand.

As fulfilling this indication with ease and economy, and without damage to boiler, foaming, or any other untoward result, I have devised a process which several years of extensive and varied practical trial have thoroughly tested. Tannate of soda is the agent used. This is periodically introduced into the boiler or heater by any convenient means, in sufficient quantity to maintain a constant excess, determined by the presence of its peculiar color in the water at the gauge cocks. It is soluble, and being constantly present as the supply water pours in, loaded with the scale-forming salts, the following reactions are constantly going on between the tannate of soda and the carbonates of lime and magnesia:

A mutual exchange of acids and bases occurs; the lime and magnesia are precipitated as tannates in a light, flocculent, amorphous form, so that they do not subside at all, but are kept circling in the boiling currents until they find their way into the mud receiver, there finally subsiding into a loose mushy sediment, which may be blown out very readily from time to time as it accumulates. The carbonate of soda formed in the reaction is retained in solution, becoming a bicarbonate by appropriation of the free carbonic acid of the water. This decomposes the sulphate of lime, the resulting sulphate, soda, is retained in solution, and the carbonate of lime is acted upon at the moment of precipitation by fresh portions of the tannate of soda.

The constant presence of the alkali protects the iron of the boiler from all action of tannic or carbonic acid, since both have a greater affinity for soda than for iron; the alkali will keep both acids neutralized as far as the metal of the boiler is concerned. The lime and magnesia, however, having a greater affinity for the tannic acid than the soda has its acid action will be operative on these bases, producing the results before detailed. The same reactions take place between the tannate of soda and the already formed scale; its exposed surfaces are gradually disintegrated, the resulting sediment finding its way into the mud receiver. This superficial abrasion loosens portions of the scale, which can be removed at intervals of one to four weeks according to circumstances, until the boiler is clean; after which it will be necessary to open the boiler only at long intervals for inspection, as the tannate of soda will keep it clean if properly used in sufficient quantities.

As the earthy carbonates and the sulphate of lime constitute the great mass of the mineral matter found in most boiler waters, and as the remaining constituents are soluble, and hence do not incrustate if the boiler is occasionally emptied, it will be seen from the foregoing that in this salt (the tannate of soda) we have an agent which perfectly fills the demand theoretically, and, as before stated, extensive trial in all kinds of water has proven its practical efficacy. It is applicable to marine boilers, as well as those using fresh water, for the marine incrustation is very similar to that formed from the waters of rivers, lakes, etc., consisting as it does principally of earthy carbonates and sulphate of lime. The chloride of sodium of sea water forms a mushy deposit if supersaturation is allowed to take place, but it is incorporated in the scale only to a slight extent, and this is prevented by more or less constant change of water, by blowing out both from the surface valve and from the sediment receiver.

EXPERIMENT.

Into this tubulated retort we will introduce our artificial hard water, together with a small portion of tannate of soda in solution. The precipitate of tannate of lime immediately forms, and in the currents of ebullition we observe that it is carried about in a loose flocculent form, very light, and showing no tendency to adhere. In the tube of the retort, which corresponds to the sediment receiver of an ordinary boiler, we observe the constant accumulation of the precipitate, which we could readily conceive might be blown off.

The length of time which I have already occupied forbids my noticing several other methods of scale prevention which have been proposed by myself and others. Before leaving the subject, however, I will mention a simple method for determining the hardness of waters and their fitness for boiler use.

DETERMINATION OF HARDNESS OF WATER.

A saturated, filtered tincture of soap is prepared of proof spirit and the soft soap pharmacopœia; also a solution of bicarbonate of lime, by passing carbonic acid gas through lime water till it becomes clear. An ounce of this is carefully evaporated and the residue

weighed. To another ounce of this solution is added, one minim at a time, with shaking after each addition, until a permanent lather is formed. The weight of the above residue in grains is to be compared with the number of minims required to produce a lather. This comparison will show how many grains of hardness will be neutralized by a given number of minims of the soap tincture. This tincture, thus roughly titrated, is to be added, one minim at a time with constant shaking, to an ounce of any water to be examined, until a permanent lather is produced. The number of minims required will indicate by reference to the last operation the number of grains of hardness. Tincture of soap does not alter by keeping closely stopped, and by this simple agent, with no other apparatus than a minim glass and vial, the hardness of any water may be determined with sufficient accuracy to decide upon its fitness for boiler use. Respectfully,

JOSEPH G. ROGERS,
Madison, Indiana.

THE PRESIDENT—Gentlemen, the discussion of the report presented yesterday is now in order.

Mr. TOWNE, Northern Pacific Railroad—Mr. President, I would like to ask the professor some further questions in reference to the precipitation of that lime and magnesia contained in the retort. He assumes, as stated by the Committee yesterday, that the flocculent, amorphose form, which the water and the sediment assumes, will hold that in that condition until it reaches the mud receiver. The Committee assert, it is a question then whether the flocculent amorphose form, which Dr. Rogers says the sediment assumes in the boiler by chemical action, and which floats in the current of ebullition until it reaches the mud receiver, where it may be readily blown out from time to time, does not lodge in its descent upon the tubes and internal surface of the boiler, while the water is at rest, and then become hard by the action of heat. Whatever sediment you gather in the end of your retort will remain there until the water comes in contact with it to raise it again. That is the view the Committee have taken of that condition of this sediment. Now, if you apply heat to that end of your retort where your sediment rests, will it not become hard in the absence of water?

Dr. ROGERS—No, sir, it will not. As far as I can illustrate this I can assure Mr. Towne that it will not. In order to illustrate, just change the boiling place. You see this is undergoing a change here for sedation. You will observe there that the sediment begins to rise immediately upon the

application of heat, and has no tendency to subside. The specific gravity of tannate of lime is such that upon the slightest agitation of the water it begins to rise. Repeated experiments have demonstrated that even if that should remain there in the retort a whole week, and then you put heat under it it would rise. That is a matter, of course, upon which it is important to have some testimony.

Mr. TOWNE, Northern Pacific Railroad—Mr. President, I do not claim to understand the chemical action upon those deposits, but after they are precipitated by the action of this chemical addition if they contained any glutinous substance they must necessarily become hard by heat, as stated here in the report of the Committee on Boilers and Purification of Water, "the floating substance must necessarily settle as the water recedes, and should it again pass through a boiler full of tubes not more than eleven-sixteenths of an inch apart without lodging upon them, just in proportion to the consistency of the roil, is not easily understood." Now, if that sediment settles to the bottom, it must lodge on these flues more or less, and if, as stated before, there is any glutinous substance in these sedimentary deposits it will become hard, and ordinary prairie mud which contains more or less clay will bake as hard as incrustation itself, almost like a stone. Therefore the Committee has contended from the beginning that the sedimentary deposit is as difficult to get rid of as the incrustation itself, even though it may be entirely free from incrustating elements. The great trouble we have to contend with in locomotive boilers is to get rid of the deposit after we have precipitated it. Suppose we can precipitate it, the difficulty is not overcome then. There is no manner of means of getting rid of it in the locomotive boiler. Therefore I have clung to the first principles with the Committee, that the only way to get over the difficulty in locomotive boilers is to purify the water in some shape or other before it goes into the boiler. Rain water or surface water of any kind is very much better than most well water in the West. All the well water contains more or less lime of some kind, either sulphate or other kinds of lime which give us the most trouble. There is a good deal of magnesia in Kansas, and also in Dakota. Rain water, or surface water, is very much better than any well water. If rain and surface water together were allowed to settle before being taken into the boiler we probably would have very little difficulty, because there would be no sedimentary deposit to get rid of. Very many of the members here have had, I have no doubt, as much experience in this difficulty as I have, but, perhaps, have not given quite as much attention to the chemical or theoretical principles of the matter. Mr. Boone, of the Pittsburg, Fort Wayne & Chicago Railroad, one of the worst roads in the country for scale, has tried all manner of experiments with boiler compounds and everything else, and does not seem to meet with any particular success. He says petroleum has done as much good as anything else, and that, we all very well

know, will not get over the difficulty entirely. There is, of course, any amount of room for discussion upon this subject. As the report is very full and contains my idea as well as that of the Committee, I will retire for some one else.

Dr. ROGERS—Mr. President, in regard to the action of tannate of soda, Mr. Towne has referred to, the difficulty of getting rid of sediments after they are once precipitated. Now, if we can succeed in precipitating sediment of such light specific gravity and of such slight tendency toward adherence, it seems to me that there ought to be no difficulty in blowing out the sediment as fast as it forms, or at occasional intervals. Now, in regard to tank depuration, as I said before, if you want a method of tank depuration there are three or four that I have mentioned that I may say will be found more or less practicable in various localities. I think that the cheapest one for general use will be the carbonate of soda used in the tank. Introduce a sufficiency of carbonate of soda in the tank and give room for precipitation and you get all your lime right down to the bottom of the tank. For that arrange a siphon so as to draw the clear water from above leaving the precipitate by itself and you will have a water which will have a very slight tendency to form scale. And really I have heard nothing which leads me to change my original conclusion that chemical means used inside of the boiler, perhaps, are as cheap as any; but it does not matter whether you use tannate of soda inside of the boiler or out of it. It will produce precipitation in the cold as well as in the boiler. I did show you that tannate acid had an action upon iron; I want to show you that tannate of soda has no action. [Dr. Rogers here performed some experiments illustrating his lecture.] Tannate alone will act upon boilers, but tannate of soda will not, simply because soda exists as an alkali, protecting the iron and everything else from any acid action whatever.

Mr. JACKMAN, Chicago, Alton & St. Louis Railroad—Mr. President, as I came up I held out some inducements to Professor Sewall, who is a professor in the Normal Institute, to come up with me, and he consented. He is the gentleman who analyzed some water for the Convention a year ago or more, and I wanted him to come up in order to see the members of the Association and to make a trip to Chicago with me. As he has of late been analyzing some scale and water for me in our region, it may be that some of the members of the Convention would like to hear some remarks from him, which I think he would be very willing to make if they should desire to hear them, with regard to his experience, so far as water is concerned. Of course I will not urge it upon the members, but I would very much like to hear him.

Mr. ROBINSON, Great Western Railroad—Mr. President, I would propose that Professor Sewall be invited to address the Convention on that subject, and would move the Convention to that effect.

Motion carried.

Professor SEWALL—Mr. President and gentlemen of the Association, I think I can please you very much by saying by way of preface that I will be very brief. I have given this subject a good deal of attention in the last three years, and I believe, Mr. President, that I have had theories enough to purify all the water that has fallen since the time of the flood; but, practically, I find myself very much in the condition that you all probably find yourselves in, still asking what can be done to prevent this great nuisance of boiler incrustation. I have consulted authorities, English, French, German, and American, and I believe, so far as I am capable of judging, from the highest authority I find that the testimony is almost universal; and I am sorry to say, for I am not here to dispute, that it does not agree with the gentlemen (Dr. Rogers) who has just spoken to you; that although means may be used to alleviate the disease somewhat, depuration before entering the boiler must be the remedy sought. In short, it is a perfect devil and must be kept out. In the experience that I have had with analyzing boiler incrustations, such as Mr. Jackman and others have handed to me, I have not known of the ingredients used; but I have found this to be true, invariably, that the quantity of matter and the quality varied but very little. As to the time the depositions were being made I have not been informed; but the quantity of matter, the quantity of sulphate of lime and the quantity of carbonate of lime, etc., I have found varied but very little; and from these three years' experience and a great deal of interest, for I have really neglected my business because I have taken so much interest in the experiments, it seems to me that water must enter the boiler free from these substances that produce incrustation. I will detain you, gentlemen, not more than two minutes longer. Now, we have here one of the precipitates; I don't remember which one. It makes no difference, you see, although it was precipitated some time ago, or the ingredients mixed, that it has not fallen down in a literal sense—it has not precipitated—it is separated and held here in suspension. In depurating water in the tank I apprehend that will be the fact. I have conceived a notion that it might be precipitated in this way and then passed through charcoal-blocked filters or something of that sort, by dividing the tank and allow it to precipitate in one side and flow over through these charcoal filters in the upper part of the tank. That would not be expensive certainly. Then we would have pure water on the one side and accumulation of deposit on the other side of the water tank. The precipitants that might be used have already been alluded to. The oxide of ammonia would be a very excellent thing, but I apprehend that unless some cheaper means could be devised for manufacturing it would not be practicable; but that certainly would produce the desired effect. So the sum and substance of all I wish to say to you, gentlemen, is that from the highest authorities I can find, and I might quote to you Blocksome,

who speaks particularly on this subject, and who is certainly a very good authority, and Racenius and Rano, an eminent French authority, who are very decided in their opinions that some plan be devised whereby the water could be purified of these deleterious matters that produce incrustation and then filtered in the upper part of the water tank so that pure water might flow over on the one side to use. But here is another difficulty. The trouble, as I find by the report of Mr. Towne, is sometimes this and sometimes that. Usually, and in fact most always, the incrustation is made up of the salts of lime—from eighty-seven to ninety-five per cent. of the incrustations are the salts of lime—but you have iron and you have magnesia and silica. Now, all these peculiar combinations, whether acting chemically or mechanically, must be treated differently, so that the location and geological section of country that you are in must determine what remedy is to be used. In fact, gentlemen, it seems to me that the report of Mr. Towne, so far as I understand this matter, is all gospel. I met him this morning and I remarked that if this had been a Methodist meeting and I had been attending I should have said amen. Thank you, Mr. President and gentlemen.

Mr. Coleman Sellers, of Philadelphia—In corroboration of what has been last said, Mr. President, and also in support of the report of the Committee, I would like to observe in reference to one particular kind of water with which we have to contend against the difficulties of incrustation: namely, that from the Schuylkill river which, according to this Table of Analyses of Waters, is a very good water indeed. That water boiled for a considerable number of years in the same boiler produces a sediment that is very hard, and I have seen it an inch thick. It is formed mainly of sulphate of lime. Mr. Whiteman some years ago told me that carbonates of soda placed in the boiler would, in all probability, answer the purpose and keep them clean. It has been used by a number of boiler users, and some say it answers the purpose and others that it does not. In one case, that of Mr. James Hunter, of Hestonville, near Philadelphia, who has large printing works, had a nest of old boilers that were condemned as useless. Instead of throwing them away entirely he passed water into the top of one and out of the bottom of it into another so that the water communicated through the whole of them and all were filled with water. The waste heat of the apparatus, the piston and the chimneys, passed over the whole of this surface and kept them heated. As has been said by Dr. Rogers, sulphate of lime is not soluble in hot water, though it is in cold. The result of applying hot water deposits the sulphate of lime, and the water passed into the boilers in a clean condition free from these salts of lime. That experiment was continued during a period of nearly fifteen years, and during the whole of those fifteen years the boiler into which this water was passed, purified in these heated tanks, never had the slightest sediment in it, while all other boilers in the establishment were coated with more or less sedi-

ment. One boiler after another of these that were submitted to heat were gradually clogged up with sediment so that they had to be torn out and thrown away, and finally the experiment ceased when the last boiler only remained. In regard to the treatment of boilers by those incrustating compounds, there are a great number of owners who have applied to us to use their compounds in our boilers. We always tell them that nothing shall go into the boiler unless we know the chemical compound of the substance. Well, they have said that that was their trade secret. "Very well, then," we say, "we can not try it; if you have not confidence enough in us to know that we will not divulge your secret then you had better go away; but if you will tell us specifically what is in this we have no objection to trying it, because we suffer, as all other people do, from this cause." In one case a gentleman explained to us what was in it, and I asked him how it was he made up the bulk that he had in his barrel of material. "Well," he says "the fact is it would not do for me to sell it in the condition it really exists because in that barrel there is one pound of substance and the rest is sawdust, and so on. It is going it pretty blind, you know, when you have to buy a barrel of sawdust to get a pound of material. That is the way he made up the profit. There is one substance that we have used in our boilers that I think must have been tannate of soda. It looks exactly like that mixture and behaves like it. It was sold to us as a patent boiler anti-incrustator. We took that finally, and I think it is the only one we did try, and from the experiment we tried with it it acts very much as Dr. Rogers shows it to act here; but it was ascertained that it would remove scale from the boiler. We tried that three different times. We have got a boiler that is what the French call *bete noir*—it bothers us a great deal. It is a heavy boiler, coated up about a half inch thick, and everything we could do for months with this preparation did not efface the scale. I would like to ask the doctor whether it is calculated that this will act upon scale after it is formed.

Dr. Rogers—I will remark, Mr. President, that there are a great many compounds before the public at the present time which are practically tannates of soda, and they are gotten up in an empirical way without any reference to proper chemical combinations. Some are neutral, some are acid, and some alkali—I could specify, perhaps, two dozen. In regard to the action upon very heavy scale, there is a specimen of scale from a rolling mill [exhibiting specimen] which in the course of a few months was entirely eradicated by tannate of soda. I would make a further remark, that if we prevent the gradual increase of the scale formation completely, the expansion and contraction of the scale from alternating heat and cold, we will gradually get rid of it. The river men are all aware that sometimes even an occasional change of water will produce a falling off of the scale in the boiler. This change of action is brought about by a change of deposits, which have no tendency to adhere to the original deposit. Being not of a

homogeneous character it readily splits off and the scale comes away. If we can devise any means that will prevent the formation of new scale the old scale will gradually come away itself; where it is excessively dense, as it is in that specimen, it is almost like agate, and many months may be required to remove what already exists. If we prevent the formation of new scale we may undoubtedly expect to get rid of our scale already formed. As to what the preparation was that Mr. Sellers refers to I do not know, but there is a considerable number of preparations before the public now, some patented and some proprietary secret compounds, which have for their basis tannin combined with various substances, and some of them are practically tannate of soda.

Mr. F. B. Miles, of Philadelphia—Mr. President, before we close the discussion I have a small mite of testimony that may possibly be of some use, at least may throw a little light upon this subject of carbonate of soda. We have in our place an upright boiler; we have it constructed especially because we have to contend with very heavy scale. Our establishment is on the banks of the Schuylkill river, and in spite of this analysis we are very much troubled with a heavy formation of scale. I think it partly owing to our being where we are, perhaps, subjected to a greater amount of residuum in the water pipes than they are where Mr. Sellers' establishment is; but, at all events, we have an upright boiler, made for the purpose, with one hundred and sixty tubes in it, the upper part of the crown sheet rounding and the fire box tapering, made of steel. At the level of the crown sheet we had eight hand holes made to clean the crown sheet off; at the bottom of the water space we had eight hand holes to clean the mud out. We tried in this boiler anti-incrustators and all sorts of sediment catchers, and everything, and our engineer happened to know that carbonate of soda, or what he called plain washing soda, would do it. So we commenced to use that on the scale, and we cleaned it readily so as to prevent a very heavy formation, but it got as much as an eighth of an inch thick on the crown sheet and in the fire box, and we then applied this carbonate of soda, and after suffering it to remain in there two weeks the plates we found perfectly clean and bright. We have never had any trouble since we commenced using it. We now apply it occasionally, perhaps once every three months, and we have no trouble whatever in keeping the plates clean, or the tubes either.

Dr. Rogers—Mr. President, I remarked in the paper which I read that, for tank depuration, the carbonate of soda would answer every purpose, because it has the desired action upon the carbonates and magnesia and lime, as well as upon the sulphate of lime. Of course, in the boiler it will necessarily answer the same purpose, and, as has been remarked, it will do admirably, particularly where there is a preponderance of sulphate of lime, and I have no doubt Professor Sewall will corroborate that statement. While I am up I would like to ask him what he meant by the statement that the

authorities did not corroborate what I said. I have spent some fifteen years studying up on this matter, more or less, and been engaged in the practice of medicine, and am just as enthusiastic on the subject as he is, and want the matter thoroughly elaborated.

Professor SEWALL—Mr. President, I am very sorry I did not succeed in making myself understood. I said I did not wish to say anything that Dr. Rogers said was not so, or in his opinion, as to which was better—to cure the disease after it was established, or to prevent the disease—was not so. I wish to say and to be understood that the authorities, so far as I know, are universal in believing and state as their belief that the better way is to prevent the disease—that is, to depurate the water before it goes into the boiler.

Mr. JACKMAN, Chicago, Alton & St. Louis Railroad—Mr. President, I have had some experience in experimenting with boilers so far as scale is concerned, and if time would admit to relate the experiments that I have made I should be very happy to do so; but to relate the experiments that I have made in full would take me at least two hours. Therefore, I will not inflict such a thing as that upon this Convention, but I will claim, if the Convention is willing, a very few minutes, and be exceedingly brief in stating some few experiments that I have made of late, leaving all of the old experiments out of the question. For a year past and a little over a year ago I have been experimenting with two boiler compounds. I am not, perhaps, at liberty to state exactly what they are, although I have had them very critically analyzed and know what they are, and I suppose that when you simmer it down to a point, if it is not the same as tannate of soda, in its action it produces the same effect that tannate of soda does. We have a large stationary boiler that has been in use some five or six years. After making it new and using it two years, and using water that contained a large portion of lime and a large portion of magnesia, a mixture of magnesia and lime, I found that it had incrustated so that on the crown sheet there was a very hard scale of more than an inch and a half in thickness; and the result of it was that it burned the crown sheet out entirely and cracked all over so that I had to take the boiler up and get the crown sheet out and put in a new one. After putting in the new crown sheet and setting the boiler at work, some time ago I took a compound, and the man wanted I should give it a thorough trial. I told him I would do so—that I would give it the most thorough trial it could have—and I gave instructions to the man who had charge of the boiler to put in as much as he saw fit, twelve or eighteen pounds at each time when he put the compound in. He has followed that now for nearly a year, and I have examined the boiler from time to time as it has been cleaned out, and to-day, although I do not have very great faith in boiler compounds or anything of that kind, if you will examine the crown sheet of that boiler it is almost as clean as that sheet of paper, and

the tubes are also almost clean. I had occasion, not more than two weeks ago, to take out two of the tubes, which we took out from the holes through which they are put in, and they came out easily and readily; and on examining them after they were out we took a little water and poured on them, and washed them off so that they were nearly clean. A while before I used these compounds, during the first portion of the time that the boiler run, those tubes in that part of the boiler where these tubes were taken out were coated almost half an inch thick. As we cleaned this boiler out we took out from forty to sixty gallons at each time, and sometimes more. I have cleaned it out about once in two weeks, and it is clear lime and magnesia, soft and plastic like mortar, or softer than mortar—it is liquid so that it will run out. We took out from forty to sixty gallons at each cleaning, once in two weeks, and by that means kept the boiler clean. I have looked into the hand holes, and held a light up to look on the wall of the fire box, and on the sides of the boiler all around, and I found that and the stay bolts clean. Then we have plugs so that we can reach through over the crown sheet and the crown bars. We take those plugs all out and put lights in all around the leg and crown sheet, so you can look right under through all the parts and see the crown sheet; and the crown sheet is very nearly clean, and has been during that time. Now, there probably is some merit in this material that we put in, and were it not for the cost of it it would perhaps be good. It is probably profitable to use in stationary boilers, but we could not use it in our locomotive boilers for the reason that it produces such a state of foaming, using it as copiously as it ought to be. So far as our locomotives are concerned I have been trying another compound. I have had that analyzed also in order to find out what its constituent parts are. I have used that very extensively, putting sometimes eighteen pounds into a boiler. Where you put eighteen pounds of that into a boiler, and if you have got a heavy freight train to pull, it will sometimes make the boiler foam; but you may put from twelve to fourteen pounds in a boiler running an ordinary passenger train, and it will run that train without any difficulty so far as foaming is concerned. There have been two or three cases where the engineers have objected to running with that in their boilers, and one in particular running a ten-wheel engine pulling a heavy train of sometimes thirty-five or forty cars up a grade. He complained that it made his boiler foam. Others use it and don't discover the difference. But I suppose where you put in as large quantities as that the result is to make the boiler foam to a certain extent. While we can get along on lighter trains where the service is not so hard, on heavy passenger trains I should not want to use it, because I should fear it would cause some foaming, and by that means retard the train. As to the results of these compounds I took two boilers and commenced with them about the same time, running in the same direction and doing precisely the same service. I run one of those ten months and the other

four months, and I found in the one that had run ten months the deposition of scale on the tubes, that this compound was on, was equal to that which had run four months. I took the tubes out and they *calipered* alike on the outside over the scale; but while the scale on the one in which the compound was used was comparatively soft, and if you took it off, was friable, the other was harder than a flint, and could not be got off except we took chisel and hammer and cut it off. Now, as to the interior part of the boiler. In this boiler that I used this compound in we have what is called a water bridge. I commenced to use this after the fire boxes in these boilers were nearly worn out, and I took them both up and renewed the fire boxes. After I got the fire boxes out I had the most ample opportunity to see what the result had been; and still in the one where we had not used any of this compound the scale was quite thick in the water bridge on the inside, and the other one was comparatively clean; and on the one where we had used this compound, if you let water through it forcibly and then rubbed it with your hand you would wash this scale all off, while on the other, where we had not used this compound, it had that hard scale on that forms on this section of our road—the section between Bloomington and East St. Louis. I could not help admitting that the effect of this compound had been to a certain extent good; but then the great question comes up again, can you afford to use it? can you afford to pay the price that we have to pay for a compound like that, and use from twelve to twenty and sometimes twenty-five pounds per week in your boilers? Does it not cost more to do that than to do the ordinary work of taking the tubes out and cleaning them and getting the fire boxes out after a certain time and putting in new ones? or, in other words, do we derive benefit enough from the use of this compound to pay the cost of using it? That is the great question with me. I will say that so far as the effect produced is concerned, the same effect will be produced by what Dr. Rogers recommends, that is, tannate of soda. In regard to another idea advanced by Mr. Towne, to the effect that these substances were as difficult to get rid of when precipitated as they were when formed in the form of scale upon the boiler; I do not exactly agree with my friend Towne in that particular, because I find that when we can precipitate the matter that is in the water into the bottom part of the boiler that it does not usually grow hard, and that we can get rid of it very much better after it is precipitated, we can find means to take it out. If it does harden eventually it takes a very long time to get hardened. We run over a certain portion of our road reaching into Missouri where we get surface water, and that water is impregnated with clay largely, and we experience no very serious results from the use of that water. We can send boilers over there that will leak on any other portion of our line so that we can not run them without fixing them, and after using that water a little while they become tight, and after a while when we want to clean them we take

out all the hand-hole plates and run water through, and run rods in there and wash that material all out, which is nothing but clay. Only a few days ago I was examining one of these boilers that had come back that had been running over there some time, and I could put my hand up in at the hand-holes at the bottom and take out large bunches of nothing but soft clay, and when a man goes to work scientifically to wash them out this clay will come out very copiously. It seems to wash out with the water, and it gives no trouble. We are not troubled with the flues leaking, and we are not troubled with the crown sheets incrustating so as to burn out, and we have very great relief when we run engines in that section of the country. I find that the great difficulty which we have to contend with is, first, the lime, which forms a hard scale; then the lime in connection with magnesia which forms magnesium limestone, and is a good deal harder than lime scale; and then on some sections of our road we get a good deal of clear salt that produces a bad effect on the iron, and on some sections of the line we have a few alkalies that form a very acrid kind of substance in the form of scale, and that produces a bad effect upon the boiler, because it will work out through any little seam wherever there is one in the boiler, and unless the boiler is made perfectly tight in the beginning you have no possible chance of stopping it except by caulking, or re-riveting, or using some means to bring the iron so perfectly together that there can be no leakage. Now, these are a part of the results of experiments that I have made in this scale business and different kinds of water, and, as I said before, if I were to relate all the experiments that I have made it would take at least a good two hours, but I will not inflict such a thing as that upon this Convention. I thank you for the very kind attention you have given me thus far.

Mr. Jeffrey, Illinois Central Railroad—Mr. President, I presume we have all had more or less experience in the use of locomotive and stationary boilers, and I think our stationary heater with lime catcher would cost, perhaps, two hundred and fifty or three hundred dollars. The interest on that would be, say twenty-five or thirty dollars, and the wear and tear might be twenty-five or thirty dollars per year more with the engineer giving it the proper attention. That would be about the expense that the company or the owner of a stationary boiler or boilers would be put to in the continued use of that kind of boiler. The discussion has assumed a little wider range than is signified in the heading embracing the question for this Committee to investigate. It started out, I believe, with the management of locomotive boilers and the purification of water. I think for the stationary boiler there can be no question but that a heater and filter combined with it would be the simplest and the cheapest. We have one in operation at the shops in Chicago, of the Illinois Central Railroad Company, which has been running there for four or five years, perhaps longer, and we do not have as much scale form in those boilers in two years as we had in three months

before we introduced this heater. It consists simply of a heater for precipitating carbonate of lime and magnesia that are held in solution. Then after the water passes from the heater it passes into the filter, and there the floating impurities are filtered out, and then the water passes into the boiler. At nights in the winter time we have occasionally used that boiler, and then the heater, of course, is worked, the stationary engine not being in operation, and we find that in winter time scale does deposit in the boiler, but in the summer time when we use the heater entirely at the time the boiler is being used, we have no deposit whatever. In regard to locomotive boilers it would seem to me also that the proper plan would be to do as the Committee recommend—purify the water before it enters the boiler. Either do that or adopt another recommendation of the Committee, and form reservoirs at convenient points along the line, and use rain water drawn into the reservoirs by the req uired slopes at the sides. The company's right of way might be utilized in a matter of that kind. A right of way, for instance, one hundred feet wide, would give over four hundred and thirty-five feet in length of road to the square acre of surface, but then we will throw out the amount that may be used for tracks; in fact, we will say that there are about fifty feet in width of the right of way actually available for surface to receive rain water. That would give in the neighborhood of forty acres, perhaps, to every twenty miles of road. Now, it seems to me, that in constructing a line of road that matter might be held in view by the engineer in charge, and the embankments, slopes, ditches, and drainage made such as to lead the surface or rain water toward the reservoirs at such distances apart as might be deemed necessary. That would avoid the necessity of going from the company's right of way for a supply of water. In regard to marine boilers, it seems to me that it would be necessary, more than with any other class of boilers, to purify the water after it enters the boiler. So, you may say, that carrying the reservoir along with them, they find the water wherever they happen to be, and whatever impurities are received in the boilers must be settled right there. I do not see any other way of doing it.

Mr. Woodruff, Central Railroad, Iowa—Mr. President, I would like to ask Mr. Jackman what class of compounds he used in his boiler?

Mr. Jackman, Chicago, Alton & St. Louis Railroad—One of the compounds that I have been using is manufactured by Morrison & Co., of Cleveland, and the other is manufactured by a man here in Chicago by the name of Lighthall. I think it is called "Lighthall's Boiler Purifier." The manufactory in Cleveland is called the "Excelsior Boiler Compound Manufactory." These are the last two I have used.

Mr. Woodruff, Central Railroad, Iowa—I would like to state a little experience that I have had with those two compounds. We have a well at our shop and it has the worst water to contend with that I have ever come across.

It is very hard, so hard that as it drips from the plunger and drips off the boiler it forms a scale in a very short time, and the boilers scale so that we have to take out one set of tubes that have not been in there to exceed a year, and we find nearly a quarter of an inch scale there, and in the fire box from three-eighths to one-half of an inch formed during that time. Previous to taking them out I used both of these boiler compounds. Now, I want to make a remark here, that in the length of a hundred miles of road the water is not all alike. Very many times we are contending with river water or well water, and with the difference in locality there is a difference of chemical composition of water. What will precipitate in one tank will not in another—one compound will not do everything for the whole line of a road. In the first place I used the Morrison compound, but I could not say that I got any good result from it. The scale kept on the increase all the while, and finally it got so bad in the fire box that it burned it out and I had to drill holes in there and run rods through to get it out. It was entirely solid in some places Afterward I got Lightall's and used that compound, but did not get any real benefit from that. Well, I got discouraged. Thirdly and lastly, there was a man who lived at the north end of our road by the name of Hewitt—previous to this I had seen Mr. James Waters, of Southern Minnesota—and Mr. Waters stated that Mr. Hewitt had tried a combination of his there and made it clean his locomotive boiler effectually. These boilers that I was trying these experiments on were stationary boilers and built just like other boilers. He said it cleaned his boilers out effectually, and I wrote to get this man Hewitt to try his experiment on our boiler. In the composition there was no secret, only he got it patented. I can tell you what it was—muriatic acid. I put into that boiler sixty-five pounds of muriatic acid. I put it around the fire box and through the hand-holes. There was where the trouble was. Then the fire box was shut and we let it stand about twenty minutes, filled the boiler with water, and got up about twenty or thirty pounds of steam, and let it stand about two hours and blowed it out. Well, he claimed that this would let the thing all loose. In a measure it did soften it, but it did not loosen it up. There appeared to be another composition in there besides the lime itself. We took a bottle of solution and put the limestone in it. It relieved the limestone perfectly, but it only eat what lime there was, but the balance of sediment, whatever it was, was as hard as iron itself, and it would not disturb it, but I could by putting in my rods where I had drilled in, and putting in a plug through the handhole, I could work this off. In a great many places I got material off the iron, say half an inch in thickness. In that way I worked two-thirds the scale off from around the fire box, and the composition, aside from that, did not do any particular good. I will remark that after using this and blowing it out, we afterward put in sal soda and molasses. The object of it was to neutralize the effect of this muriatic acid in case it tended to do any

damage. I think the molasses and soda did about as much good as the rest of it. Finally, I had to take the flues all out and put new flues in the boiler. Since that time I have been using sal soda alone, and the deposit has not been near so much. The boiler is washed every week. The engineer puts in about six pounds of sal soda every week and the deposit is nothing to what it was previous to that, but it makes the boilers foam for the first two or three hours, after that it don't trouble during the rest of the week. But there is so much difference in the composition of water on the line of roads from one end to the other, that the trouble is there is no one composition that will answer the purpose.

Mr. JACKMAN, Chicago, Alton & St. Louis Railroad—Mr. President, I want to make a statement in regard to the use of muriatic acid. I know physicians sometimes give us tremendous doses of calomel and then give us a dose of salts afterward to counteract the effect, and I should think that sixty-five pounds of muriatic acid might pretty effectually fix a boiler. They bring us, perhaps, twenty different boiler compounds, and they are pretty expensive sometimes if we make the experiment as thorough as possible. With these last two that I have used, I started out with the idea that nothing should stand in the way of my making the experiment as thorough as possible. As to the result and as to what I would recommend: As I stated in the first place, the one that we used in the stationary boiler we could not use at any rate in locomotive boilers because it would make them foam, and the other that we did use in the locomotive boiler we could not use as extensively, as it ought to be used in order to produce a good effect. Then, again, in regard to the different kinds of water that we have, take the whole section of our road, while they may work very well in one place they might not work well in another, but in the use of them as extensively as I have used them, and as thorough as I have made the experiments, I could not say but that they had done *some* good; still I have no great faith in boiler compounds for getting rid of scale. That is what I want the Convention to understand. In the first place, if you find a compound that will do it you have got to use so much that the cost of it is more than that of cleaning the boiler by the other process of taking the tubes out once in twelve or fifteen months, and putting in new fire boxes when the old ones burn out. The sum total of what you pay for these compounds you put in the boiler for cleaning, and washing will do but little more than make new those parts that you burn out, so that if possible, and if these compounds are feasible so far as expense is concerned, to purify the water before it goes into the boiler is undoubtedly the true method. The boiler compounds are a good deal like a patent medicine. I have a little anecdote that I sometimes relate to these men who bring boiler compounds along, and it is this: Along in 1854, when the cholera was in the country, I happened to be in a section where there was a good deal of it. There was a certain physician who attended a

man working for me who had been taken sick with the cholera in the afternoon, and this physician gave his attention to him until nine o'clock in the evening when he left him, and another man and myself stayed with him until he died. This physician that had gotten up this compound purposely to cure the cholera, came along the next day, and says he: "I thought I had a preparation that would knock the cholera higher than a kite. I was perfectly sure of it until I tried it on that man, and now I think my medicine might cure a mild case of diarrhea, but it isn't worth a penny for the cholera." It is a good deal so with these boiler compounds.

Dr. ROGERS—Mr. President, following the remarks of Mr. Jackman, I would say that medicine is not an exact science; being a physician myself I am able to answer and make that statement dogmatically, but chemistry is an exact science. In regard to the treatment of this question of the purification of water, whether it is in the boiler or out of the boiler, in my opinion, makes not a particle of difference. If it is thought best by the Association to recommend purification of water by tank depuration it is very easily accomplished. But I think that the general opinion of the Association is rather wrong, at least that is my opinion, in regard to the feasibility of the plan of the purification of water inside boilers so as to prevent the formation of scale. I have been much pleased with the remarks of Mr. Jackman, in regard to the feasibility of getting rid of sediment, and his statement corroborates my own theories.

Mr. HUDSON, Rogers Locomotive Works—Mr. President, I agree mainly with the idea of purifying the water before it is made use of for locomotives where that is practicable, but we all know that there are many railroads where it is entirely impracticable, and that they have to resort to some chemical method, or chemical and mechanical combined. It is very important that the water should be kept from forming these solid deposits in the boiler, and in the use of these compounds, I think in place of using them in very large doses they should be used in small doses; and in getting rid of the deposit there ought to be some mechanical means devised for collecting these deposits near the surface of the water, because they all come to the surface so long as the boiler is in active operation, and blowing them out every hour or two. In that way they are not allowed to accumulate so as to be injurious or form in the shape of hard scale or get in the mud drum, a place for the sediment to deposit. It is important that the matter should be got rid of as the water is evaporated. The mud drum at the bottom of the boiler is of no use for the collection of this matter so long as the boiler is in active operation. The mud, or what separates from the water, will settle there the moment you stop using the boiler. A separator to be useful must be near the surface of the water, and at that portion of the boiler where it is as far as possible removed from the agitation due to ebullition. In other words, if it gets into this mud trap it must not have any oppor-

tunity to get out. In Cuba, where the water is of a very bad character, sediment collectors have been placed in many of the boilers, near the surface of the water, and they are so constructed that as the water flows through them the mud gets through and settles there because there is no current and it can not get out. It is used in connection with a surface blow-off cock, which is periodically opened, and by that means this matter is got rid of. With regard to one argument of our friend Jackman, who says that he does not know whether it is better to suffer the evil of burning the boilers and having to replace them or use these compounds, I will say a word. I think there is one element he has not taken into account. It is not simply having to replace the tubes and the fire boxes, but it is the additional fuel that you have got to burn when the boiler is all scaled up. I think when Mr. Jackman comes to count the whole cost he will find it is very much in excess of using some reasonable and common-sense compound for removing the scale.

Mr. Jeffrey, Illinois Central Railroad—Mr. President, I desire to ask Mr. Towne one or two questions. In the first place I would like to know if the Committee made any estimates in regard to the cost of purifying water before it enters the boiler?

Mr. Towne, Northern Pacific Railroad—No, sir.

Mr. Jeffrey, Illinois Central Railroad—I think that that is quite an important consideration. The main point with railroad companies will be as to the cost of the different methods; is it cheaper to use boiler anti-incrustators and these various compounds, or is it cheaper for one thousand gallons to purify the water before it enters the boiler, or is it cheaper for one thousand gallons to have reservoirs for catching rain water? I think, gentlemen, that those are important points, and it would be well to have a careful estimate made in regard to the cost in each of the three cases; and I thought perhaps the Committee had taken that matter under advisement and had some figures to offer.

Mr. Towne, Northern Pacific Railroad—I would state to the Convention that the expense of purifying water was very generally referred to in former reports, giving the cost of purifying water by certain processes and the cost of extra fuel necessitated by the increased formation of incrustation, taking, for example, the figures as given by some of the best authorities we have. It is stated in Dr. Rogers' paper, as well as in other papers that I have noticed, that scale the thickness of the sixteenth of an inch will require the extra expenditure of fifteen per cent. more fuel. As the scale thickens the ratio increases; when it becomes a half an inch thick, or even three-eighths of an inch thick, the heat necessary to heat water through that scale will convert iron into the state of cast iron. I wish to say a few words in reference to Mr. Jackman's statement concerning the deposit of sediment. I have some statistics here to prove its effect, and before reading that I will

say that if our engineers and other boiler managers were perfectly reliable or infallible, we could depend on them to get this sediment out after it became loosened by the use of boiler compounds. It seems to me hardly necessary to discuss the matter of boiler compounds. Everybody knows that there can be compounds prepared, and that there are, that will soften boiler incrustations. You can prepare a compound that will dissolve any kind of stone—boiler incrustation is nothing more nor less than stone itself in some form or other—and we will admit, must admit, that the scale can be dissolved; but the question comes in whether we get rid of this difficulty by dissolving the scale or not. I contend, sir, that we do not in locomotive boilers, and I claim that it is quite impossible to do so. Now, it is stated in this report, regarding the injurious effects of the deposit of sediment that, referring to the inspection made by the Hartford (Connecticut) Steam Boiler Inspection and Insurance Company, for March, October, and November, 1873, the whole number of boilers inspected during the three months was 7,173; of this number 2,161 were inspected internally and entire, 3,290 were found defective. You will notice a very large number of boilers were found defective; cause, incrustation and scale 587, dangerous 50. When boilers are not cleaned frequently impurities in the water become concentrated and act very injuriously on the iron. Suppose you put your compound into your boilers and soften the scale, what good does it do unless you blow it out? It is still in the boiler and you must get rid of it or you gain nothing. Do your engineers open the blow-off cocks every day? I think there is not one of you who will say they do, and why? Because we do not enforce it. We find it almost impossible to do that. I have discharged engineers on my own road within the last three months for failing to comply with the rules in reference to using the cocks to blow sediment out of the boiler. But this does not even get them in the way of using them properly. It is a matter of great difficulty to get them to attend to it. Nobody attends to it on stationary boilers particularly. Of course those employed in the management and running of stationary boilers and engines are not generally, and in fact very seldom, as competent men as locomotive engineers. We have some very competent and intelligent men running locomotives, while some of them, as all understand, are quite to the contrary. Deposit of sediment 570, and 82 dangerous, 20 of which were very bad. The whole number of burnt plates which were attributed to the deposit of sediment 207; dangerous 87. It will be seen that nearly half of the whole number of defective boilers became so on account of incrustation and deposits of sediment; and, strange as it may seem, there are forty per cent. more dangerous cases from the deposit of sediment than from incrustation itself. This was an inspection made by the Steam Boiler and Hartford Insurance Company, who make it their business to insure boilers and buildings in which boilers are kept and run. The Committee state here, "This evil in locomo-

tive boilers is as difficult to overcome as that of incrustation itself." Now, I would like to know if it is not? Can you wash out a locomotive boiler after you precipitate the lime and the incrustation? How can you clean out the cylinder part of the boiler without taking out a flue? Suppose you have a hand-hole plate in the front end, in the flue sheet, then how are going to get at it unless you lay your engine up for two days to do it? It can not be done. You must take your boiler in and lay it up for that purpose, and there is not a road in the country that could spare their engines for that length of time except the Northern Pacific, where we have forty off service just at present. I don't see how you are going to get over this difficulty unless you purify the water before you take it into the boiler. The business of the Committee is not for any particular patent, or any thing of the kind. Tannate of soda, no doubt, will remove a large proportion of this incrustation by dissolving it. The boiler compounds spoken of here, I have no doubt, are just as meritorious; but the question is, will they remove the difficulty? As I stated before, the business of the Committee is to submit to this Convention a feasible, plausible remedy, something we know will produce the desired effect. You may recommend, if you please, these boiler compounds for the removal of this scale, and it might be adopted by this Convention, but in two years' time we would run right back into the same old channel we are now in; we would have just the same difficulty to contend with that we have at present, from the fact that just as soon as the excitement, or whatever you may term it, subsided, men would get careless about the use of the article. There is no use of using any thing at all unless you keep it up. I have no doubt that some boiler compounds if put into the boilers and they were washed out properly, and it was followed up, would remove all the scale. Perhaps tannate of soda will do the same thing. But can you do this practically? Will you do it, and will it pay you to do it? Here is an article spoken of in this report called steatite talc, or pulverized soapstone, which is spoken of very highly by foreign engineers and parties in Paris who have tried it. If it will do the work as well as other boiler compounds, or if it will soften the scale, it would appear to be the cheapest thing of the kind because we have soapstone all over our country. It underlies the soil of the Northern Pacific nearly its entire length, and probably would not cost a cent a pound pulverized in shape to use. I have just commenced to use it simply for an experiment. I speak of it because it is so highly spoken of by these parties who have tried it. Marie, chief engineer of the Paris, Lyons & Mediterranean Railway, says that it has a very desirable effect upon his boilers. You will notice that the blowing out and washing of the boiler must necessarily come in. After you loosen these incrustations you have got to get rid of them. You will notice right in the very place where you want to wash are steam pipes and exhaust pipes in the front end in the way of it, and it is a very difficult thing

to get at; so it seems to me that if we use boiler compounds at all that it must be followed up, and your engine must be laid up for the purpose of washing them out after you put them in there. I can not really say any more than is said in this report. There are, of course, some little points connected with the subject that it might be well to discuss, though so far as boiler compounds are concerned there is no question but that they will soften the scale. The question is now, how shall we get rid of it? I desire to show the Convention, while the subject is before them, a sketch of a reservoir for the collection of surface water. There are very many places in Dakota where the land is very much as through here. This sketch is almost fac simile of one place we have there. There are very many places in Illinois, in fact, in all States where a dam can be thrown across a ravine and the surface water collected so that you can get heighth enough from your track to employ a small water crane in connection with flumes. By letting water from the reservoir into one of these flumes and allowing it to settle, and taking it out through the water crane, you will get pure surface water free from sediment. I have found in all my investigations that the sediment is the worst thing we are troubled with. Of course incrustation is a very bad thing to get over, but if we used surface water or rain water, in which there is a great deal less lime and other incrustating impurities than in well or river water, we would get rid of this deposit held in suspension, and we would have but very little incrustation in our boilers. There is not sufficient lime or other impurities contained in this surface water to incrustate a boiler or flues to the thickness of a sixteenth of an inch in two years' time.

Mr. HUDSON, Rogers Locomotive Works—I would like to ask Mr. Towne if he can introduce filters into those reservoirs?

Mr. TOWNE, Northern Pacific Railroad—I contend that a filter is not necessary. Filtering is a slow process of purifying water, settling is just as good, if it is not better. There are two flumes or tubes represented here on this sketch, and one of them is intended to settle the water while the water is being used out of the other, and alternating in their use. This is arranged so that whenever the water is let in sediment deposited can be washed out.

Mr. MILES, of Philadelphia—I would like to ask Mr. Towne whether the action of this steatite talc is chemical or whether it is mechanical in its action, like starch or potatoes—whether it merely forms a nucleus for the action of these particles of carbonate and sulphate of lime?

Mr. TOWNE, Northern Pacific Railroad—The analysis of steatite talc is given in the report.

Mr. MILES, of Philadelphia—Is steatite talc chemical in its action, preventing incrustation, or does it merely act as the other mechanical substances

do, such as starch and potatoes? I do not mean the chemical constitution of steatite talc, but its action.

Mr. TOWNE, Northern Pacific Railroad—I am not prepared to say what that action is. I simply have it here in the report as I received it from other parties. Perhaps Dr. Rogers can give us some light upon this subject.

Dr. ROGERS—In answering Mr. Miles' question I would say the substance can have no action whatever except as he suggests—exactly the same action as starch and other gelatinous preparations—namely, it constitutes a nucleus for the deposit of the elements of scale formation to save the iron. If I mistake not, in this report there is something mentioned of that sort. Certainly, in looking over the chemical constitution, I can see no action it can possibly have upon the scale other than that of forming a nucleus for its deposit. One thing I want to say in regard to sedimentary deposit. We must get the sediment. Talk about waters which contain no sediment originally. Sea water contains no sediment at all. The scale that we have formed from rain water is harder than any other. The sediment we get from operating chemically upon rain water must be of a sort and of such a specific gravity and of such non-adherent qualities that it can not possibly form a scale. If it is of light specific gravity the sediment which is produced by chemical action upon such waters will necessarily be of a non-adherent quality. That is what we want to obtain, and any agent that will produce a sediment of this character in the boiler will answer the purpose perfectly. If you will observe this retort you will see that the sediment which is formed is perfectly light and flocculent. It would have no tendency to adhere to iron. Other chemical agents will produce the same result. That is what we have got to do—produce a sediment which can be gotten rid of instantaneously without diverting the locomotive from its duty for any length of time. There are a variety of chemical agencies that would certainly accomplish this end. This statement is readily demonstrable, and we have a demonstration of it in the experiment here before us. Now it seems that the question of getting rid of the sediment has become very important. I think a proper course of experimentation will satisfy any member of the Association that it is quite possible to produce a sediment that can be readily gotten rid of. It is an easy matter to get a sediment that will not then incrustate because of the residuary heat in the boiler. If you allow this retort to remain here for a week or year, then on the application of a lamp to that portion of the tube where the sediment is now gradually collecting, that sediment will rise and pass around through the current of ebullition, just as it has been doing now. I think that is a sediment that only requires a little experimentation upon to produce complete reduction. In regard to the use of chemical agencies inside steam boilers—I am not a very rich man, but I will guarantee that quite a variety of chemical agents can be arranged and introduced into steam boilers, the cost of which will be paid for over and over again by the cost of fuel

which is saved, and I will contract to keep any locomotive boiler clean with tannate of soda, or carbonate of soda, and with a variety of other means, for the cost of the fuel saved.

Mr. JACKMAN, Chicago, Alton & St. Louis Railroad—Our time, I know, is about up, but with reference to some remarks of my friend Towne, I wish just to make a simple statement. He seems to think that we do not wash boilers effectually. I wish to explain a little as to what we do. We have a regular corps of boiler washers at every place where we have an engine house. If the engine house is small, and there are only a few engines, there is one man; at our Bloomington engine house we have four whose whole business is to wash boilers. The question is how do we wash them. An engine comes in, and as soon as it has cooled down a little so that we can take the fire out, before the steam goes down, we open the blow-off cocks and take out one or two hand-hole plates at the bottom, and let all the water out as forcibly as ten or fifteen pounds pressure of steam will carry it out. A man then opens the front of the smoke-box and takes out a hand-hole plate in the bottom part of the cylinder of the boiler, and puts a hose up in there and washes out through the tubes as much as he can. Then they run rods through and wash it all down. They take another hand-hole plate out on the front of the leg of the boiler. As a large portion of our engines have the water-bridge in, that lets them out into the water-bridge so that we can run the rods up all through that part. Then we take out four hand-hole plates on the bottom of the leg of the boiler. Then we have, just above the crown-sheet, on a level with the front of the sheet, five or six, and sometimes eight blocks, so that we can reach in under the crown-bars, clear through to the crown-bars between every row of rods. Then I have adopted another plan. Our boilers are mostly boilers made on the wagon-top plan, and on the front part, just front of the flue sheet on each side, I cut a large hole two and one-half or two and three-quarter inches in diameter and cap it, and screw brass plugs in there. In addition to all the other, we can take those brass plugs out. Then we take those plugs out and put a light down in there, and take a hook and hook all the loose stuff that we can find out, and run a rod down between the tubes as far as we can, and put a hose in there and wash it at the same time; so that we wash just as thoroughly as we can all through the boiler. It has been asked how often we do this. On our road we do it as often as once or twice each week. No engine is run more than a week without its being washed, and many of them are so cleaned twice each week; and we always run water through until it comes out clear. Then, with regard to this sediment that settles from the use of boiler compounds, I will direct my attention more particularly. An engine came in in which the compound had been used for a long time—a month or two—and I wanted to see what the effect would be. The engine had a mud drum. I blowed off, and I think there were about sixty or eighty gallons of loose mud that came down. That

is different from anything we had ever had before; and that attracted my attention more particularly to the compounds that might be put into boilers to dissolve the scale; and that shows also with what readiness it can be gotten out. I think all of our Illinois Master Mechanics, particularly, know something what washing boilers mean, and I think that all roads in Illinois go pretty extensively into that business. I think it costs them some money too; and I know that we wash our boilers effectively, and I believe all the rest do.

THE PRESIDENT—I would state to the Convention that on yesterday you voted to call up the question of the mechanical laboratory at twelve o'clock. If there is no objection, before we take up the mechanical laboratory question, we will have a recess of ten minutes.

THE PRESIDENT—The business in order now before the Convention is discussion on the mechanical laboratory, which report was read yesterday. Before the discussion I wish to say that there is a Committee on Subjects for another year's discussion, and that any member who has subjects he wishes brought before the Convention to be acted upon during the year, can avail himself of the opportunity to present it to that Committee that it may be presented to this Convention. All subjects are requested to be presented before two o'clock this afternoon. The discussion on the report of the Committee on Mechanical Laboratory is now in order.

MR. SETCHEL, Little Miami Railroad—Mr. President, I move that the report of the Committee be divided, and that the paper of Mr. Thurston containing the proposition from the trustees of the Stevens Institute be laid on the table for one year.

MR. OSBORN, Grant Locomotive Works—I was about to move that the whole subject be referred back to the Committee to report at the next annual meeting, and I will offer that motion as an amendment to the motion before the Convention.

MR. SETCHEL, Little Miami Railroad—I could not accept that amendment.

THE PRESIDENT—Then the question is on the original motion.

MR. CHAPMAN, Cleveland & Pittsburg Railroad—Mr. President, would not the laying of that report on the table prevent its being printed in our annual report? I think it would, as it was received and, as I understood, was to be printed in the report.

MR. SETCHEL, Little Miami Railroad—I would then modify my motion by moving that action upon that part containing Professor Thurston's letter be postponed for one year.

Motion carried.

THE PRESIDENT—The discussion of the papers presented by the Committee as an appendix, which were prepared by Professor Thurston, is postponed for one year, but will be printed in the report. The discussion in order now is on the original report of the Committee.

Mr. JACKMAN, Chicago, Alton & St. Louis Railroad—Mr. President, although I do not pretend to say anything particular upon this subject, yet, as no one seems to be willing to open the ball, I will say a few words in regard to it. In what I said yesterday, so far as the laboratory was concerned, I expressed the opinion that the laboratory was a very valuable thing, but with this understanding, that it might be impossible for us to have a laboratory connected with this Association, and located in some particular place, that could be made useful to all the members of the Association and to all the roads with which those members are connected. Now, there are one thousand and one things in a railway line that we want to test. For instance, the question is often asked of the Master Mechanic, how many cars his engine can haul? or, what is a load for an engine to take? and I always think if they want to put on to an engine all that it can pull and then add one car after that, I always say to them when they ask me a question like that, after we know the size of the cylinders to the locomotive we know the length of the stroke to that locomotive, and we can determine in our own minds how much pressure of steam it is advisable to carry in order to pull loads over the road—after we have fixed that, then, if we know the grades in feet and inches, we can very readily approach the point as to how much the locomotive can pull up those grades. We, for instance, figure up what the tractive power of that engine is, and then, if you put on more cars—that is, if you put on a sufficient number of cars and a sufficient amount of weight—expecting that engine to surmont a certain grade under those conditions, you have got to carry steam enough in your boiler to counteract this force of gravity which has to be overcome in going up the grade. In the first place, we want to fix with a dynamometer how much in pounds it requires to propel the ton over the track that is level or ordinarily level; then, after we get at that point, when we get to the grade—after we know the rise per hundred feet—we can figure how much additional power will be required to draw this ton up that grade. This can all be determined by the dynamometer, because, if we have one that is thoroughly reliable, attach it to the engine and then to the train; let the engine surmount the grade, and it will show how many pounds are pulled in order to take that train up the grade. If we have this dynamometer, and if we have all this other apparatus connected with the laboratory, and it is situated down in the State of New York—in New York City, for instance—is it so situated that all the roads, or a considerable portion of the roads, may be able to make a good and scientific use of it. This seems to me to be the only objection that there is to the establishment of this laboratory. For instance, in another point of view which I spoke of, we want to test the strength of certain iron or a certain wood, or any other substance of which we want to test the tensile or the transverse strength, we have got to do it by making use of some instrument by which we can test this. Now, what I thought was like this, that

are so many men engaged in that business—the United States Gov- ent and all the governments of any considerable proportion on the face e earth are all the time engaged in testing the strength of iron, and in g the strength of steel; and besides governments there are various iduals—there are manufacturing establishments that are doing that; f we undertake to do it ourselves we get no better results than those ated statements which we get now in a printed form; and if we can not y better, if we can not get any better results than what are already ht before us, would it not be a useless expense, so far as we are con- d, to do that? For instance, here is a little portion of a laboratory on the before you for testing water, and if we should carry it on to a very con- able extent we should want a considerable of a laboratory. Dr. Rogers ell us something near what we should want if we went extensively into business. Inasmuch as there are so many chemists employed all the and as they are publishing, from time to time and from year to year, esults of the experiments they make, is it possible, or if possible, is it ible that we should get any better results than what we get through chemists that are all the time engaged in this business, who give us tabulated statements, and who give us the results of all the experi- s they make? That is the question that I want brought out, and that ild like to have discussed by the members of this Association. I hope every one will be free in the matter.

. Hudson, Rogers Locomotive Works—I would say with regard sting apparatus and with regard to chemical apparatus, I think the itude of the railroad interest of this country is very much greater the interest of some private establishments that employ chemists have a laboratory of their own. I believe it is the practice of a great r of these brewers to keep a chemical laboratory. They have a chemist whose whole time is devoted to that subject. Again, in an iron manu- ry, these blast furnace men in making the iron it is necessary for to have a chemist, and they keep one. Again, the large manufacturers on have all the means of testing both the tensile and the tortional and strength of the material they are making, and it is not that we are not to get accurate results, or the results of their experiments; as Mr. Jack- says, they are already tabulated; we can get access to them, but that is what we want. Many of us can recollect that a few years ago there was ich thing as Bessemer steel—Bessemer metal, if you like so to call it. e was no such thing—it is a new metal—and there are various quali- of it, not only of Bessemer but of other steels that are in the market. we want to test some particular brand—we want to know whether it is ted to the purpose for which we require it, and therefore we want some ratus by which we can test it. A railroad like the Illinois Central, the New York Central, like a great many other of our large railroads

in the country, could afford to have all this apparatus belonging to them selves, and they ought to so have it. In the absence of that it devolv upon the Master Mechanics of these railroads to furnish themselves wit the necessary apparatus for arriving at conclusions, which may be importa for the purpose of carrying on their business; and in that view of the ca I think it is important that the Master Mechanics' Association should ha some apparatus, at least, and some means of determining these questio that may come up from time to time. It is true there are difficulties wit regard to locations, and many other points. It may be said that the things are not all accessible; a man may have to travel two or three tho sand miles, or get the apparatus sent to him. That is all very true, and i the long run it will pay for doing it.

Mr. SELLERS, of Philadelphia—It seems to me that there is no doubt all but what a laboratory of the kind spoken of would be of very great u to the community at large. There is no question but what it would be very great use to the members of this Association; but, as I said yesterda the very fleeting nature of our Association, the constant change of membe ship, and the wide separation, involves difficulties that it is very hard t overcome. I think it would be well if there is no action taken, at least th year, in regard to the establishment of such a laboratory, to make caref investigation of the experience of similar societies abroad, as, for instanc the Society of Mechanical Engineers in England, which is really a ve celebrated association, composed of mechanical engineers from various pa of the world. Mr. Robinson may be able to state whether they possess mechanical laboratory, but my opinion is they do not. I think there a some troubles which would be quite difficult to overcome in the formati of such a laboratory, but which we may be in time able to overcome. B the great value that would accrue to the community at large from such laboratory is not the testing of particular specimens of metal that we mig want, but the original researches of the professors who might be engag in them. Tyndal said at the end of his lectures, quoting De Tocquevill that scientific research would never prosper in a republic. I don't kno that De Tocqueville was right; but, in fact, I am inclined to think th he was wrong, that there are a great many gentlemen in this country e gaged in original research that ultimately will be of great use to the m chanics at large. There is no doubt but what we must all borrow fro knowledge obtained by other people, and it is not in the experiments th we ourselves may suggest, but in the line of experiments that will be co ducted by those having charge of such an institution. But I think that th members of the Association would find themselves lamentably behind in th formation of such a laboratory if they expected that it would benefit the directly in any investigation that they might wish to make for the tim being. It has been said it would be a very good thing to be able to sen

our oil to such a place to be tested. If we did that we would probably find the people in charge of the apparatus were too busy to test all the oils sent. Judging from my experience as to the quantity of oils forced upon us by the manufacturers, we would have to keep it running pretty steadily on the oil question and nothing else. I do hope that whatever is done in the future there will be no hasty action in regard to it now.

Mr. JEFFREY, Illinois Central Railroad—In connection with this matter I would remind you how often it may be material to test different substances for different purposes. On our road we make it a habit to occasionally test material of different kinds that are used. For instance, if a new brand of iron is sent us for use in the boilers, or for use in any other part of our machinery, we may require a good quality of iron and we have to test the tensile strength of that. We have a very simple arrangement for that purpose, consisting of a hydraulic wheel press to press on driving wheels. We simply attach to that a heavy lever, and let the ram come up and press against the heavy lever and so tear the iron in two and get the tensile strength of it. I presume every month we make more or less experiments in regard to the tensile strength of iron in that way; also in regard to the strength of stay bolts in one-sixteenth inch sheets, three-eighth inch sheets, or one-fourth inch sheets. We also test five-eighth and three-fourth inch rivets in that way. If we have a lot of rivets sent us of which we desire to know the quality, we simply arrange to tear them in two by this hydraulic press, and so we obtain the tensile strength of the rivet. And in regard to the breaking, that is the tortional strength of the iron, we have found various ways of testing that. We have also tested the lateral strength of axles, a number of years ago, by inserting one end of the axle in heavy upright blocks and then loading the outer end of the axle; so by putting in axles of half a dozen different makes we get the relative values of each. Then in regard to oils—all the oils used all over the road we receive at the Weldon shop. It is expected that the oils will be examined and tested there; and if rejected they are of course not passed into use. There is no doubt a great deal of value to the different railroad companies to be derived from instruments and apparatus which they do not now use. For instance, I think we should have an indicator in order that we might take diagrams of the action of the steam in the cylinder with different kinds of valves, valves of different proportions of outside and inside lap. We have not an instrument of that kind. In my view I think that every important railroad should have just such an instrument as that, because there is no one thing that indicates the action of the steam or the usefulness of the valves so well as the indicator. I might, perhaps, enumerate other instruments that would be of equal use and equal service to the railroad companies. Now, it seems to me, if railroad companies find it to their interest to make instruments of this kind, and the representatives of these railway companies come here in Con-

vention, and either verbally or through their written communications, give their experience in these matters that the Convention can get the benefit of it. For instance, your Committee on Boiler Incrustations has given you as complete a report on that subject as could be done by a professor in a laboratory supported by the Convention; and, with regard to other important matters investigated by the Convention, I have no doubt that the committees appointed on those subjects investigate them just as thoroughly as it is possible, and collect evidence from all over the country; in a great many cases collect evidence of the utility of different methods of proceeding, all of which the Convention derives the benefit of without going to the expense of a laboratory which, as one or two of the gentlemen have remarked, would be removed no doubt from a great many of the railroads. If it should be in Chicago, for instance, it would be inaccessible to all Eastern roads, and if you locate it East it would be inaccessible to Western and Southern roads.

Mr. HUDSON, Rogers Locomotive Works—While experiments for determing the tensile strength of iron made with the ordinary hydraulic press, as used by railways, may answer a temporary purpose, I know that it is very unreliable for the reason that we have no reliable hydraulic gauge by which you can determine the absolute pressure. I often have a dozen hydraulic gauges upon a press, and by testing them with the safety valve and lever and weights, I find that they would vary from each other several tons to the square inch, and where there is a variation, or where there is liabile to be a variation of that character, I would like to know what the test is worth? certainly not very much unless you have gone to the expense of some reliable apparatus, and it would not pay for simply pushing on driving wheels to do that. Where you want to know the absolue strength of iron it is very important that you should have better apparatus than is ordinarily used.

Mr. JEFFREY, Illinois Central Railroad—I will say by way of explanation that the gauge used was a five hundred pound gauge, and we had it carefully kept to that; and every three months, if there is any doubt about it, or as a general thing perhaps twice a year, we send the gauge and have it retested, so that we may know it is accurate. And the arms of the press are of sufficient dimensions to allow us to tear an iron of half a square inch area by using this five hundred pound gauge. I am aware, however, if we used a gauge such as are generally placed on hydraulic presses, showing out of five or eight hundred thousand tons a variation of three thousand tons, it would be rather unreliable.

Mr. HUDSON, Rogers Locomotive Works—I have never seen a reliable hydraulic gauge. The nearest approach I have been able to get at was one made of a hardened steel rod, ground up after being hardened and worked through a leather band and properly weighed. That is the nearest approach

to it that I have been able to get, and I can arrive very much nearer with that than any hydraulic gauge that I have found.

Mr. ELLIOTT, Ohio & Mississippi Railroad—This whole question of laboratory seems to be as to whether we require to know to a precise point what is contained in all the different matters that we have to deal with, in the shape of water and so forth. Now, the great question with me is whether I would require that in my practice as a Master Mechanic—whether those experiments made by Master Mechanics in their rough way are not equally as good for practical purposes as those that are worked down to a very fine point—and that is all I can perceive that is to be obtained by this laboratory. If we establish this laboratory it has got to be managed by men that are experienced, and they can only tell us as we are told in books what results they have obtained. In the report on incrustation of boilers the report goes right down to simple things, and whether the means suggested would take out every ingredient contained or not is not very important for us to know—we take out all that we can in practice. I came here to hear the experiences of different Master Mechanics in the past year, and what they have done, what they have tried, and what they have found out, and to tell what I have done myself; and for my part I can see no good results to come out of this laboratory that we can not get by making application in our individual cases. If I have got any particular thing that I want tested, I get that tested, and my company on my application or statement of the case will, I have no doubt, always pay the expenses of having it done. I think that the whole matter can be reached in that way. I for one am not prepared to come here and pay for getting up a mechanical laboratory, nor a chemical laboratory. I come here in the interest of the company I am connected with to learn all I can, and to go back and endeavor that my company shall get the benefit of it. I am serving them all the time, I think, in this view of the case; and, looked at practically, that we really do not require anything of this kind in the nature of our organization.

Mr. WOODRUFF, Iowa Central Railroad—I concur with Mr. Elliott's remarks that a laboratory belongs strictly to the chemical department, and we are in a mechanical department. My object here is to gain information in mechanics, not chemicals particularly; of course, I pick up what information I can, but I want to know how we can make an engine the most serviceable. It is the power the companies are after; they want something that will pull cars, and we want to get all the power that we can out of a certain size of cylinder and stroke, and we want to work that to the best advantage—the most economical. That is the main point, as I understand. There are men here that have had a great deal more experience than I have. As far as I am concerned I have not had charge of the mechanical department but a short time; but I have been connected with the railroad business for eighteen years, and I would like to gain experience from those who know how to make parts of the engine the most

serviceable, and get what knowledge I can in that respect. That is the main point that brings me here.

Mr. HUDSON, Rogers Locomotive Works—I think that the business of the Master Mechanic involves really more than simply mechanical business. Perhaps there is a question of case-hardening. We all know that the durability of many parts of the locomotive depends upon the perfectness of the case-hardening. Now we might have quite a long discussion on the subject of case-hardening, but it is a chemical process. It is true that mechanics perform it; but the bottom of it is chemistry. Now, if we want to know whether something else is better than what we are using, we ask the question of competent authority, is such a thing good for anything. Again, if we want to weld a piece of copper, we want to know what will prevent the oxydation of copper, so that we may be able to weld it; or we want to weld steel and a great many other things. Now, in all these instances connected with the locomotive in its construction and its operation, and in many others, chemistry is involved from beginning to end, not only in construction but use. The combustion of fuel involves that question, and the whole question of water is chemical and mechanical combined.

Mr. ELLIOTT, Ohio & Mississippi Railroad—I admit that, but the supposition is that mechanics do not come here to know about case-hardening. It is not necessary for them to send to a chemist to find out anything about the process of case-hardening. If I want to know what to use for case-hardening—for instance, the best process—I ask Mr. Hudson what to do. He tells me, and I know simply it will do just what he says. There is no necessity for further action in the matter. It is just so with all the things we can mention connected with the road. We are all chemists to a certain extent—there is no question about that—and we must be; but the fine point that is required by a chemist I don't consider comes into our business in practice.

Mr WOODRUFF, Iowa Central Railroad—I think the way Mr. Elliott puts it is the correct one. We are all practical men, and we can gain information one from another. The chemist would not take an interest in getting the knowledge for us that we want in our every-day experience, nor can he get it. He doesn't know the working of the thing. He may take a piece of iron, and realize a certain effect from its composition; but we have got to experiment among ourselves, as in case-hardening, for instance. And case-hardening is an item that amounts to a great deal in the course of a year. I can give you a little experience in that, that is in the quality of case-hardening; I won't mention the class of engine—I have several classes to deal with—but one class of engine I have on the road, the case-hardening of the links has run nearly three years, and to-day they are almost as good as the day they came on the road. There are other engines that we could not run a year without taking a a sixteenth inch off the links. I wrote, in one instance, to the builder of these engines, and asked him how he case-hardened the links. He wrote me his

answer; what kind of iron he used, what to be particular about, etc. I could see through it in a minute—could see the reason of it. It is a great point with him. He takes particular pains about that one item, and that one item is worth several hundred dollars to a railroad company in the course of three or four years. Now in case-hardening we have got to try it a great many different times; we have to do it quickly. We can't pursue the regular process of case-hardening. (Mr. Woodruff here read an extract from a newspaper setting forth a certain process of case-hardening.)

Mr. HUDSON, Rogers Locomotive Works—I will simply say with regard to that process, that it is one that was peddled round the country some years ago by a man claiming to own a patent for it; at any rate he was going round the country selling rights to use that secret. That is all I can say about it.

Mr. WOODRUFF, Iowa Central Railroad—It may be a patent; but, however, if it is a patent it is a good thing; something new to me.

Mr. HODGMAN, Philadelphia, Wilmington & Baltimore Railroad—I have listened with very great attention to the various members that have spoken with regard to the expediency of having a laboratory. I think that the very fact that we wish to gain knowledge is one proof that we ought to have a laboratory. What is it we want to gain? We want to gain what we don't possess. Are we ready to pay for what we want to gain? If we are not, I think we are scarcely worthy of the position we stand in; though I would advocate that the laboratory be postponed for a year, yet I feel quite convinced that it is absolutely required, and I think it would reflect the greatest credit on this Association that there should be one. The bulk of those tabulated statements found in books are frequently of great age, and we wish to be in a state of progress. I think we should all be pervaded with that spirit.

Mr. JACKMAN, Chicago, Alton & St. Louis Railroad—I am very well satisfied with that disposition of the subject; but I would suggest that it be put into the hands of the same Committee that have had it in their hands for the year past. I believe that the action of that Committee is entirely satisfactory, and I do not believe that any new committee could be obtained that would treat the subject any better, or furnish a more satisfactory report than the Committee in whose hands it has been for the past year. It might, perhaps, be well that the Committee be instructed to confer with the Committee of Civil Engineers of New York, but giving the Committee unlimited powers in the conference.

Mr. JEFFREY, Illinois Central Railroad—I move that the discussion of the mechanical laboratory be deferred, and that it be referred back to the Committee that had it in charge last year, to report at the next annual meeting; and that they be authorized to confer with the Civil Engineers of New York.

Motion carried.

THE PRESIDENT—Before the Committee on Fuel for Locomotives makes its report, I will state that the discussion on boilers seemed to be taken away from the Convention for room for this laboratory discussion. I don't know but what that should properly come before the Fuel Report, unles ssome one should move that it be dispensed with.

Mr. ROBINSON, Great Western Railroad—I believe it is in order to continue that subject. I would like simply to remove any impression that may be conveyed to our railroad companies in consequence of a misunderstanding of what Mr. Towne has said, and I scarcely think he meant exactly what he said when he referred to what was supposed to be a fact, that very few railroad companies had sufficient locomotives to wash their boilers out very frequently. Now I think I shall be supported by a large number of this Convention, when I say that any railroad company who does not supply its Master Mechanic with sufficient locomotives to enable him to have boilers cleaned out properly and regularly, is just as deficient in its duties to the interest of its stockholders as a Master Mechanic would be to his employers by allowing his boilers to go dirty. When Mr. Towne said there was very few railroads I think he made a mistake.

THE PRESIDENT—He was speaking of a peculiar way where it would take two or three days to wash them out by some apparatus that he was explaining.

Mr. ROBINSON, Great Western Railroad—By removing the mud-hole plates and blocks, and all that kind of thing, I think it occupies ordinarily twenty-four hours to wash a boiler out properly without injuring the plates by too rapid cooling. I am speaking of course of the Great Western, that she may not stand on a wrong footing in this Convention. Our rule is very definite, and the locomotive foremen in charge of the engines are compelled, at the risk of losing their positions, to have each engine under their charge washed out by removing the mud-hole doors and plates and blocks, and thoroughly washing out after every run of five hundred miles, and certainly not to exceed seven hundred miles. Last year we had not sufficient engines to do this in consequence of the very heavy traffic, but more engines were asked for and they were supplied. I think that is the right course to take, and therefore I submit to the Convention that the careful washing out of the locomotive boilers is more important than incrustation powder. The experience of the road which I represent is no doubt that of many others. We have tried a great number of incrustation powders; we tried one where we paid one hundred dollars for each boiler. Twelve or fifteen of these boilers were successfully treated till we got to the Lake Ontario water, there sulphate of iron mixed with lime was found, and that beat the agent entirely; he lost some three hundred dollars, and then stopped. But I am under the impression that he was using this cholera powder that is manufactured in such large quantities, or something of that kind. Certainly,

taking it altogether, I heartily indorse Mr. Towne's remarks, and the report of the Committee, with this statement qualifying that portion of his personal remarks in this Convention.

Mr. TOWNE, Northern Pacific Railroad—It is not my intention at all to charge our railroad companies with not furnishing sufficient power to operate a railroad, but I think nearly all the Western men will bear me out in saying that there are times during the year on Western railroads when our business is such that it is almost impossible to spare an engine long enough to wash her out. I often run engines six weeks or two months, simply blowing them off at the blow-off cock without having time to wash them, keep them constantly in service night and day, sometimes change the men but keep the engine doing business. At other times of the year we have more force on hand. That was what I was referring to, and not censuring any railroad at all. They are disposed to furnish power to do the business generally if they can. I would like to call attention to a matter concerning the use of reservoirs. Mr. Salisbury, superintendent of the rolling stock of the St. Louis & South-Eastern Railroad, has had considerable experience. There are several of them located along the line of his road. The waters in that locality, he tells me, are of a very incrustating nature, and that since the adoption of the reservoir he has had no trouble at all with incrustation. I have no doubt he can give us some items concerning the expense of these structures, and the expense of keeping them up, etc., which we would be very glad to hear from him.

Mr. SALISBURY, St. Louis & South-Eastern Railroad—The matter before us I happen to have been individually connected with right after its construction. I know that we could get no water in the wells that we could use, and my attention was directed to the subject of reservoirs. We have now several of these reservoirs in the length of our road—one hundred and sixty-one miles—using surface water exclusively, and the scale is something that is unknown with us. We run boilers two or three years, and we have no scale but what you could take off with your knife or finger nail. As Mr Jackman remarked, this necessitates a little more frequent washing out, but there is nothing but what an ordinary washing out will remove. The insertion of the hand in the blocks at the top of the fire box will remove it entirely. In regard to the cost of them I suppose our road could hardly be taken for a criterion, because we have paid some little attention to this in the construction of the road. We selected the localities—the natural depressions of the land. But, I have no doubt, in our section of the country that by a very slight expense sufficient water could be obtained that would enable us to use to a great extent this surface water, and remove a great portion of the difficulty. We use them entirely. We have not a drop of well water on the road, and we have no scale but what I could take off with a jack-knife.

Mr. TOWNE, Northern Pacific Railroad—What sort of a dam was required?

Mr. SALISBURY, St. Louis & South-Eastern Railroad—In most of our reservoirs we required just a very small dam on the track, and put in a bridge with a tressel over it, for a very little expense. By selecting the natural locations along the road we lessen the expense. I suppose older roads would have to go to more expense. Last season we got short of water, and we made new reservoirs. I don't think we spent three hundred dollars outside of the cost of the land for extension of the bank, only ten acres of land, and the wall, ten feet deep.

Mr. ROBINSON, Great Western Railroad—I would like to ask you, Mr. Towne, when you spoke about blowing out the boilers, if your experience would prove that the blowing out of the locomotive boiler, at the end of each journey, twice before it is taken into the engine house, would be sufficient?

Mr. TOWNE, Northern Pacific Railroad—No, sir; I don't think it would. The only proper way to use the blow-off cock in the mud-drum, is to use it every trip, and use it when the steam is at the highest pressure, so that you can produce a force that will take that stuff out of the boiler that comes within the reach of the eddy. The simple matter of using that blow-off cock once a week, or once a trip, after the engine has stopped, amounts to a very little. The time to use it is when running when you have the highest pressure. Otherwise the mud-drum is no more use than a hand-pump.

Mr. ROBINSON, Great Western Railroad—Do you take it to the ash-pan, or under the ash-pan, so as to prevent the dust being blown on the machinery.

Mr. TOWNE, Northern Pacific Railroad—That is a matter of preference. I don't know that there is any particular benefit in placing it there. Some have claimed that they let the water through the ash-pan that the particles of fire that may be lodged there may be blown out, as they are apt to set fire along the road. I think it may be a very good idea, but in most cases I have instructed the engineer not to open them, that there might be no injury to persons or property.

Mr. SALISBURY, St. Louis & South-Eastern Railroad—The use of a blow-off is almost indispensable in using this surface water. We have to use that frequently, as often as two or three times in the course of a journey.

Mr. WOODRUFF, Central of Iowa—Mr. Towne was speaking about the trouble of getting rid of the sediment. Now, in the absence of a mud-drum, I have taken out about five flues at the bottom of the boiler, and in the boiler I have laid a two-inch gas pipe, perforated with holes, about three inches apart, a quarter of an inch hole, and at the end of that a rod laid right up on the end of these pipes, and then all the mud and substances that flow there, pass through these holes. I have only got this on one engine, and what the result will be I can not tell, because it has been used only two or three times, and I have not taken the flue out to see. In time I shall make

a careful examination to see what the result will be. I think it will, without doubt, be a benefit to the boiler.

Mr. MILES, of Philadelphia—There is one point here, Mr. President, which it seems to me attention has not been called to sufficiently. The analysis of water which we have, is, no doubt, of water in its normal condition. I have no doubt—and, indeed, it has been my own experience—that a great portion of the trouble from scale and incrustation arises from turbid water, which is not in its normal condition—after a rain, for instance. On a road which I had charge of on the Island of Cuba, a few years ago, we had a great deal of trouble with scale on all parts of the island, as there is carbonate of lime and same sulphate of lime in the water, and wherever we tried that principle of using surface water—which we did by constructing dams in some of the streams, using hydrants to force the water up into tanks—where we did this we used a powder in the water, and the result was that we poisoned a number of people by so doing. We didn't kill them, but they were taken seriously ill. We used, among other powders, Morrison's boiler powders; and several parties drank this water from the tanks, and took very sick, with a severe visitation of cholera and such like imfirmities; and we found, after a rain, these water-tank reservoirs which we formed, would be full of surface water, and then we would be troubled with sediment. Mr. Towne remarked that the sediment troubled him quite as much as the incrustation, or nearly so; and, as I understand, there is no remedy for the sediment except the washing out. The very reservoirs that are made to collect the surface water will, in all cases after rains, be filled with mud and sediment, and the water will take from the land whatever mineral substances it may contain, and saturates itself with them, and there will be both sediment and incrustation. It depends, of course, upon the time of the year, and also on the land where it happens to be. If it is in a clean sandy soil it will take up but very little impurity; but it is sure to take some. The town of Liverpool has very much trouble with its water supply, which is caused by the mineral and vegetable matters contained in the soil. They have to filter the water, but filtration will only remove the mechanical; it will not remove the chemical impurities. With regard to boiler powders, they are all, I believe, either tannate of soda or carbonate of soda; and I can not see any object in buying them. I remember a case where they came to us with a welding powder, which turned out to be nothing but concentrated lye, which will weld almost as well as borax, and is, of course, very much cheaper.

Mr. ROBINSON, Great Western Railroad—I beg to propose a vote of thanks of this Convention to Dr. Rogers and Professor Sewall for their time and trouble in interesting themselves for our benefit to-day.

Motion carried unanimously.

Mr. ELLIOTT, Ohio & Mississippi Railroad—I move to close the discussion of this subject.

Motion carried.

THE PRESIDENT—The next business in order is the report of your Com mittee on Fuel for Locomotives.

Thc Secretary then read the report.

Report of the Committee on Fuel for Locomotives.

"*On the Actual Consumption and Cost of each kind of Fuel used per Mile Ru per Weight of Train hauled, including Cars; also the best Form and Proporti of Tube and Fire-box Heating Surface to Grate Surface requisite to prod the best results with each kind of Fuel.*"

To the American Railway Master Mechanics' Association:

GENTLEMEN—Your Committe on the above subject regret to sta that they have received but seven replies in answer to their circul of questions issued to the members of this Association, and are the fore unable to make a report therefrom that can prove worthy of t subject or of interest to the Association.

It is but fair to state that, perhaps, our members who are at pre ent actively engaged as Railroad Master Mechanics, are not entire to blame for this seeming negligence on their part, in not answe ing fully and clearly the circular of your Committee on this su ject. When we take into consideration the fact that but few of o railroad companies allow their Master Mechanics to provide the ne essary means of obtaining practical and therefore valuable inform tion on this important subject of fuel, the reason why our circula did not meet with a more general and able response is easily under stood.

It is true that to obtain such information would entail additiona expense, as accounts must be kept for each locomotive, of the kind quantity, and cost of fuel used, the actual mileage made, the weigh of train hauled, etc., and the comparative results computed there from—this extra expense is presumably, in many instances, th main cause of objection to the keeping of such accounts—it is evi dent, however, to any who have given the subject their considera tion that, with a thorough practical knowledge of the matter, saving, at least, in the cost for fuel would be a certain resul and to an extent that ere long would much more than compensat for the expenses incurred to gain such knowledge.

NAME OF ROAD.		Average speed in miles per hour, ex-	Average weight of trains hauled, cars included, in tons of 2,000 pounds....	Average pound each 1, Hard Coal..........	
Atlantic & Great Western Railroad............	Pa	40	275	....	to 1
	Fr	15	425	....	to 1
Eastern Railway (Massachusetts)...............	Pa	40	250	....	to 1
	Fr	25	540	....	to 1
Flint & Pere Marquette Railroad...............	Pa	25	151	....	to 1
	Fr	10	2209	....	to 1
Great Western Railway of Canada..............	Pa	32	220	....	to 1
	Fr	18	500	....	to 1
Memphis & Charleston Railroad...............	Pa	25	125	COST.	to 1
	Pa	25	125	56 cts.	to 1
	Fr	15	360	41 cts.	to 1
	Fr	15	360	....	to 1
Terre Haute & Indianapolis Railroad.........	Pa	30	113	....	to 1
	Fr	15	410	....	to 1
Delaware, Lackawanna & Western Railroad. (Bloomsburg Division.)	Pa	25	110	227	to 1
	Fr	15	475	95	to 1

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The Committee would recommend that this subject be continued another year; and, as we think the desired information could be more generally obtained and would admit of better arrangement as a report, would respectfully suggest that it be divided into subjects for two separate committees. The one relating to, "The Actual Consumption and Cost of each kind of Fuel used per Mile Run, per Weight of Train Hauled, including Cars;" the other, "On the best Form and Proportion of Tube and Fire-box Heating Surface to Grate Surface requisite to produce the best results with each kind of Fuel used."

Our circular, as issued, contained fourteen questions. The answers received in reply to questions one to thirteen inclusive, are contained in the annexed Table of the Report of the Committee on Fuel for Locomotives.

Question 14. Do you consider that the cubic contents of the smoke box seriously affects the consumption of fuel? If so, what proportion of smoke box compared to fire-box area do you consider the best for burning—hard and soft coal and wood respectively?

This question has been replied to as follows:

W. A. Robinson, of the Great Western Railway of Canada, states: "It does; inasmuch as that a very small smoke box involves a very sharp blast to be kept up to maintain the required draught on the fire. European practice suggests that the cubic contents of smoke box should not be less than three feet per superficial foot of grate area, and consider the following best proportions: For hard coal, three cubic feet smoke box to one superficial foot of grate; for soft coal, three and one-half cubic feet smoke box to one superficial foot of grate; for wood, three cubic feet smoke box to one superficial foot of grate."

C. R. Peddle, of the Terre Haute & Indianapolis Railroad, writes: "I consider the plan, generally in use in this country, of extending the barrel of the boiler as a smoke box gives ample dimensions for a smoke box. This, in the case of the freight engine (dimensions of which are given herein), makes the cubical contents of the smoke box equal to thirty-nine feet, or almost three times the number o

square feet in the grate surface—the formula used by Clarke in pro portioning smoke boxes of coke-burning engines."

Respectfully submitted,

CHARLES GRAHAM, *L. & B. R. R.*,
L. S. YOUNG, *C. C. C. & I. R. R.*,
B. H. KIDDER, *Late of the A. & G. W. R. R.*, } *Committee*

On motion, the report was received.

THE PRESIDENT—The next business in order is the report of your Committee appointed to attend the series of experiments made by the Government on boiler explosions.

To the American Railway Master Mechanics' Association:

GENTLEMEN—Your Committee, appointed to attend a series of experiments to be made by the Government, respectfully beg leave to report that the experiments are to be continued, and your Committee would desire further time.

Respectfully,

H. M. BRITTON, *Chairman.*

On motion, the Committee was continued another year.

Mr. JACKMAN, Chicago, Alton, & St. Louis Railroad—Mr. President, it may be possible that, if there should be time, there may be members here who wish to discuss that subject, and if disposed of now it could not come up any future time during our session for discussion. I do not know that there is any one who would feel any disposition to discuss it. I think that these experiments of 1873, so far as I can learn with regard to them, did not amount to much; the result didn't turn out anything very valuable, and it might be well to discuss that subject.

Motion to refer report back to the Committee was carried.

Mr. SETCHEL, Little Miami Railroad—Some two years ago we had a report from the Committee on Boiler Explosions, and, from some little informality, the Convention thought best to lay that report of the Committee on the table, and it lies there yet. I would move that it be now taken from the table and referred to the Committee on Boiler Explosions.

Motion carried.

THE PRESIDENT—One of the Committe wishes me to call the attention of the Convention to the fact that when these trials come off it will probably be noticed in the papers, and the Committee wishes that as many of the members of this Association as can do so will attend and witness these experiments for themselves.

On motion, the Convention adjourned to Thursday, nine o'clock A. M.

THIRD DAY'S PROCEEDINGS.

THURSDAY, MAY 14, 1874.

The Convention met pursuant to adjournment, at nine o'clock A. M.

THE PRESIDENT—A short time since the Supervisory Committee invited associate members to prepare some papers to be read before this Convention. Some of the members responded. Our associate member, Mr. Coleman Sellers, has prepared a paper which he will read before the Convention this morning. Gentlemen, I have the pleasure of introducing to you Mr. Coleman Sellers.

Mr. Sellers then read the following paper:

Civil and Mechanical Engineering.

The Metric System in our Work Shops; will its Value in Practice be an Equivalent for the Cost of its Introduction?

BY COLEMAN SELLERS.

GENTLEMEN—In compliance with the invitation of the General Supervisory Committee, as expressed through your Secretary, that, as an associate member of the American Railway Master Mechanics' Association, I should prepare a paper on some subject relating to the objects for which this Association has been organized, I have decided to call your attention to a matter which may before many years be forced upon you, and which you should be prepared to consider with care; I allude to the proposed introduction, by legislative enactment, of the French system of measurement, known as the metric system.

It is not my intention to discuss the subject in all its bearings, for it is a theme requiring more pages of manuscript than I would care to inflict upon you, but I will state in as few words as possible how the proposed change would be likely to affect the work shops of the land. It is now about three-quarters of a century since the metre was first made the legal standard of length in France, and during that time it has been adopted by other countries, either in full or in part; so that the advocates of its universal adoption claim that the proportion of the population of the globe already enlisted in its use

numbers 420,000,000. Hence they argue that, for the sake of a uniform metrological system all the world over, England and the United States of America should also adopt it to the exclusion of our present system of inches, feet, etc.

Many of our leading colleges are making the metric system the method of measurement in all their teaching, with a view to sending their graduates into the world as advocates of what to them seems so perfect a system.

There can be no doubt that it is very desirable to have uniformity, not only in regard to measurements of all kinds, but also in money, as such uniformity would certainly facilitate trade and advance our knowledge of the works of other countries. Those who use the metric system in all scientific matters find it wonderfully well adapted to facilitate calculation. In spite of its long names it is easily understood by persons of moderate education, and can be used even by those who have no idea of the Latin and Greek words from which the names are derived. If the world, as we know it in our arts and trades, were to be made over again, and we were obliged to adhere to ten as the base of our arithmetic, it would, doubtless be a good thing in some respects, but very unhandy in more respects, as not admiting of binary division. I have heard it declared by men of high intelligence that its introduction now is retarded only by prejudice, by the unwillingness of people to give up what they are used to, and the necessity of learning certain new rules and methods of thought. Unfortunately, may be, there is something more than these objections that will retard its introduction. The change involves the expenditure of money, of very large sums of money. When this cost is presented to our minds, we may well consider whether the results to be obtained will warrant the expenditure.

The late Senator Sumner was its earnest advocate, and at one time was determined to push the adoption of the metric system. He said to one of our most distinguished scientists: "I am content to have it legalized in 1870 and to have its use then optional, but in 187– I would make its use compulsory." The gentleman to whom he addressed himself asked if he had well considered what a tax such a measure would impose on the country. "We have now in use," he said, "in all kinds of trades, the pound as our unit of weight, and

Messrs. Fairbanks and other scale makers have for years been making platform scales with beams graduated to pounds. The edict that abolishes the pound will necessitate a change in all these machines for weighing. All their beams must be removed and regraduated to the new unit at an enormous expense." He instanced the change in the weight unit as the one most readily made, as it in the main affects perishable property only.

On February 8th, 1870, a resolution was passed in the United States Senate, that "The President be requested, if not incompatible with the public interests, to invite a correspondence with Great Britain, and other foreign powers, with a view to promote the adoption, by the legislatures of the several powers, of a common unit and standard of an international gold coinage," etc. In accordance with the spirit of this resolution, a dispatch was prepared by the Department of State.* In this paper, after recounting the requirements of such a unification in coinage as shall not prejudicially affect our interests, it says:

"It is to be observed that an identity in the measures of value in the different countries will not completely attain the beneficent results which are sought, unless there be also an identity in weights and measures. * * * * In commercial transactions an identity in measures of value would be of comparatively little use if unaccompanied by identity in the measures of the quantities to which those values are applied. There would still be a necessity for the intervention of an expert to shift the expressions of the measures of quantity, from the terms used in one country, to those in use in the other. The resolution of the Senate does not contemplate the extension of this correspondence to these points; nor in my judgment would it be desirable to do so.

"It would probably not be difficult to induce the people of different countries to adopt a common standard of weights and measures so far as perishable property is concerned. At first the adoption of unaccustomed systems might cause inconvenience and discontent, but if they should prove to be better than the old ones, and if they should have the further advantage of being common to several countries which possess a common standard of value, and which have extended commercial relations, it is probable that the inconvenience would be patiently submitted to, in view of the greater benefits to be derived from the change.

* See U. S. Report on Foreign Relations for 1870.

"But it seems to the Government of the United States that a forced change in the measures of distance, as applied to imperishable property and the permanent investment of capital, may be attended with more serious inconvenience. Thus while it may be practicable to establish a new standard of length measure for articles of international commerce, such as textile fabrics which are consumed and do not remain, it may be more difficult to make the same change in the standard for permanent values. A few examples will demonstrate the difficulties that would probably attend a change in such measures in this country. * * * * * *

"It is the custom in the United States to lay out all towns and cities in regular quadrangles, and to divide each quadrangle into an even number of lots with an even number of feet. This has been found a convenient mode of dealing in town and city lots and in town and city houses. To make an arbitrary change, which should abolish these measures and substitute different ones in their places, involving the use of fractional numbers, would occasion great inconvenience, and might check the dealings in this species of property, and cause a loss to those who happened to be holders at the time of the change. Again, the whole system of titles in those States which have been created out of the public domain rests upon government survey, whose results are expressed in the English mile and its subdivisions, rods, feet, and inches. To substitute a different measurement would be a work of serious magnitude.

"Again [and this is what most seriously affects our interests], the manufactories of the country are filled with machinery, whose delicately adjusted parts, measured in feet, inches, and component parts of the inch, work together in one grand whole, which is in its turn combined in the same system of measures. To produce this machinery thousands of shops are filled with costly plans, adjusted upon the same scale, whose delicate operations often require a nicer determination of measurement than can be obtained without mechanical aid. To transmute these measurements, so delicate and accurate, from the present system into a new one, would appear to be an almost endless labor, if indeed it be a possibility."

To show how clearly these statements express the difficulties that would attend our adoption of the metric system, I will call your attention to certain conditions of the mechanic arts in America, perhaps not fully appreciated by those who think the change is one of education only.

Eli Whitney, whose name has always been associated with the invention of the cotton gin, started, in 1798, an establishment for the manufacture of small arms on the principle known as the inter-

angable system, carried out by the use of hardened jigs or forms the same shape as the parts to be produced, thereby making all rts of guns alike and interchangeable one with another. He in-duced the use of milling, by means of revolving cutters, those ricate shapes needed in gun work. When he proposed to Thomas fferson, then Secretary of State in Washington's Cabinet, to make arm modeled after the approved French Charville flint-lock, in ich all parts of all guns should be interchangeable, he was ridi-led by both French and English ordnance officers. The govern-nt aided Mr. Whitney, and in 1800 the present Springfield Armory s established, and Mr. Whitney's inventions and system put in force ere. It was not until 1855 that the English War Department was rced to adopt the same system, importing a large amount of ma-inery from America for that purpose.

This was not the only branch of the mechanic arts that was ben-ited by this interchangeable system. America, contending with gh labor, has been forced to exercise ingenuity, and make labor-ving machines produce cheaper work. This could only be done carrying the interchangeable system into other processes of man-facture; and American clocks, watches, sewing machines, and all e countless small articles of hardware, are made by machinery, ch piece like the others. Recognizing the absolute need of this terchangeable quality in everything manufactured, but few trades xist in this country that do not avail themselves of its advantages. radually separate and distinct manufacturing establishments have ome to use the same standards and to make their production inter-ange one part with another. Witness the various devices making what is known as line shafting, as also all the screws and fittings steam, gas, and water pipes, and now the so complete recognition he American system of screw threads for bolts and nuts. The ary object of this Association may almost be said to be to in-roduce uniformity in all parts of the great railroad system of the nited States. There is no country in the world where the value uniformity in the devices used in common by all mechanics, is so lly recognized as in this land of ours. What has been done in is direction, and what is being done now, is founded on the inch the unit of measurement in the machine shops.

The machine shop, however, is not independent of other trades, and it is necessary to a proper understanding of our subject, that we have a clear perception of the nature of this inter-dependence. Machines made of metal have parts cast and parts forged. Wrought-iron is procurable in bars of certain merchantable sizes. When rolling mills are obliged to make round iron, differing in diameter from these merchant sizes, the price per pound is increased as special appliances and extra care is required. So the mechanical engineer conforms his proportions to the procurable sizes of bar iron, and uses the iron, as far as possible, without the expense of re-forging into other sizes. This is noticeably the case in regard to rounds and squares. The tools and appliances in the machine shop have in time been made to conform to these sizes, and are all expressed by the division of the inch into halves, quarters, eighths, and sixteenths. All the gearing in the country, all the patterns of cog wheels, are spaced in the teeth, by pitches, measured in inches, and the binary division of the inch, $\frac{1}{4}''$, $\frac{1}{2}''$, $1''$, $1\frac{1}{2}''$, etc., pitch; or, in number of teeth to the inch in diameter, called in practice per-inch wheels, as 12, 10, 8, or 6 per-inch, meaning so many teeth to each inch in diameter; as, for instance, a wheel three inches in diameter cut to ten per-inch, has thirty teeth, *i. e.*, $10 \times 3 = 30$. The patterns of gear wheels, in some instances, form no insignificant part of the stock in trade of large machine shops, and the immense number of wheels now spaced to pitches in inches must necessitate the continued use of them, whether we call the pitch $1''$ or 25.38 mm.

When the metric system was introduced into France, all machine work was done by hand; the planing machines for metals, and all the various appliances known as machine tools, with the exception of the turning lathe, were almost unknown. Sizes expressed in one measurement or another, were of less moment than now. I dare say many of my hearers remember the time when the rule of thumb was the mechanic's rule; when the "boss" chalked out on the carpenter's bench a thing about "so big," to be made in metal, and then some other thing was made to fit it; at such time it mattered little what standard was used as measure. While French savants were laboring to build up this decimal system of interchangeable measures, the better class of American mechanics were solving the problem of making

machinery with interchangeable parts. I am perfectly willing to concede that there are work shops in the land, in which the change from the inch to the meter could be made at very little cost, simply because these shops are furnished with no special devices for measurement even at this day ; such drills and mandrils as they may have are altered in size at the whim and fancy of the workmen. The proprietor of one of this class of shops asked me, not many years ago, if we had a pattern of spur wheel of some pitch and diameter ; and when I asked him if he had measured the diameter at pitch line of wheel, he wanted to know what the pitch line meant. Metres would do for that man quite as well as inches. Such machinists, in stating dimensions, use the terms full and scant to express fractions which might be quite readily stated with accuracy ; sometimes, however, indulging in the extra expression of a "leetle full scant" for very nice measurement.

A well-furnished establishment is provided with gauges, mandrils, reamers, standard drills, and boring tools, as well as all other appliances needed for accurate work made to certain fixed sizes, and in most shops these special tools amount in value to large sums of money. The nomenclature of the sizes of these tools, as expressing the work they are expected to do, is part of their economical use ; thus, an inch reamer is expected to make a hole exactly one inch in diameter, and no great effort of memory is needed to designate its size ; but this same inch reamer will make a hole 25.38 millimetres in diameter — which is the same size expressed in French measurement.

In the machine shop the unit of measurement is the inch—it is not the foot nor the yard—we express in inches all measurements of objects that may sometimes be made less than one foot in side. Thus, pulleys are rated as 5″ or 10″ or 72″ in diameter. Boilers are spoken of as being 36″, 42″, or 48″ in diameter. Car wheels are 30, 32, or 36 inches in diameter. For all calculations in the drawing rooms we use the inch and its decimal divisions, corresponding exactly with our dollars and its division into halves, quarters, eighths, and sixteenths. As in money, we say half a dollar or fifty cents with equal facility, so in measurement we have the half inch or .50 inch, each as expressive of size as the other.

The advocates of the substitution of the metric system for our favorite inch, say we have only to give new names to these sizes. This we can do ; we can call our inch 25.38 millimetres, or, if we prefer, we can call it the twenty-five hundred and thirty-eight hundred thousandths of a metre ; or we can call it two centimetres, five millimetres and thirty-eight hundredths of a millimetre. They say, further, we can make a slight change in our sizes, and dropping the fractions of the millimetre use the even millimetre ; thus our familiar inch would be replaced with the twenty-five millimetre size, which is a decidedly "scant" inch. As an appendix to this paper, I give a list of all our usual fractions of the inch, and our even inches up to twelve inches expressed in metric measurement.

Let me now explain how this change of size is to be brought about ; that is, what we must do if we are obliged to give up our inch. The drawings of all our machines — drawings that have accumulated through many years, and are expressive of enormous sums of money and the best mechanical talent of the land—must be gone over and all the sizes changed. To express in millimetres the present sizes in inches would never do—it would involve us in a sea of fractions that would drive any ordinary brain crazy. No, we must alter all the sizes to the nearest even millimetres. Thus, some dimensions, marked three inches, must be changed to seventy-six millimetres, .14 of a millimetre smaller than three inches, and some other size must be altered to make up the loss. Think of the labor involved in such a change, and you will not require me to say what such a change will cost. But it is said new work can be made to the new sizes, and the old sizes can be continued for the time. This is exactly the point I wish to reach in the statement of trouble and cost involved.

Drawings made twenty-five years ago are in use to-day, and drawings made during each of the succeeding years are many of them in use, and the tools and gauges are perfected to manufacture machines in accordance with these drawings. To-day we begin new drawings with the new dimensions; the change can be readily made in the drawing room. It requires no vast amount of education to substitute one drawing scale for another. We send the new drawing into the machine shop and then the cost begins; all our old tools of fixed sizes, all our old gauges are wrong, new ones must be made, and we

must run the risk of mistakes from the simultaneous use of two standards. Now, for your information, I have taken the trouble to make a careful estimate of the cost involved in altering or making new (for we dare not alter all the taps, dies, reamers, mandrils, gauges, and the other guides for the workmen in an establishment fully equipped for say two hundred and fifty machinists), and the sum foots up to twenty-seven thousand dollars—more than one hundred dollars for each man employed. This does not contemplate any change in existing drawings; should we attempt to alter all the drawings, I can not see how, in the same establishment, the change could be made at a cost less than one hundred and fifty thousand dollars. What do you think of such a change at such a cost? Would it not indeed paralyze this industry?

President Barnard, in his very able report in favor of the metric system, or rather in favor of some unification of measurement, says: "I do not expect that this system will make its way in the world against the will of the people of the world. I do not expect that our people, and I do not desire that any people, shall be coerced into receiving it by the force of 'imperial edicts' or by the terror of bayonets. What I do expect is, that they will sooner or later welcome it as one of the greatest of social blessings. What I do expect is that they will one day become conscious of the many inconveniences to which they are subjected from the anomalous numerical relations which connect, or rather we might say, disjoin the several parts of their present absurd system; inconveniences which they have learned to endure without reflecting on their causes or suspecting that they are unnecessary in the nature of things; and that when at length fully awake to the slavery in which they live, they will burst the shackles and rejoice in the deliverance which the metric system brings. This can not take place, of course, until the people are thoroughly informed."

Business men in all times look at the cost of each change. School-men see beauties in the metric system and train their pupils as its earnest advocates, but they do not count the cost. If it is needful to make the change it can be made more cheaply to-day than to-morrow, more cheaply this year than next. While the schools educate the people to see its advantages, the money value of the permanent plant

to be changed is increasing more rapidly than the uninformed on this subject can appreciate. Changes in such things as standards of measurement have been made in other countries, and changes, if needful, can be made now; but the question may in all fairness be asked, is it needful in this instance? So far as my own experience goes, having had the opportunity to use the inch and millimetre in one and the same establishment for many years, using one with as much familiarity as the other, my choice is most decidedly in favor of the inch as the unit of measurement in the machine shops and on the railroads of the country. That others think so too, in regard to one question in mechanics, let me prove by an example. Many years ago Mr. Whitworth attempted to establish a uniform system of screw threads based on the inch as its unit. His scheme met with such success that now, with the exception of France only, all the metre using peoples of the world have adopted the Whitworth system, and it has even been largely adopted in this country. It is considered better and more convenient than the French system. According to Mr. Whitworth's system, a half-inch screw should have twelve threads to the inch; to express this in the metric language, a bolt 12.7 millimetres should be 2.12 millimetres pitch. I have said business men count the cost before making changes in matters of habit or use, but when they can be shown that they will be gainers by the change they give in to it heartily. This same example of screw threads will serve as an illustration. Mr. Whitworth's system of screw threads was already introduced in all the principal work shops of Europe and in many in this country. But a better system was presented to the Franklin Institute, a system based on such simple laws that, given the formula with no existing original to copy, any careful workman can originate a given thread that will match those in use. After an exhaustive debate on the subject of its introduction by the various departments of our Government, and a careful consideration on the part of our mechanical associations, it came to be adopted as the United States standard. It was adopted at considerable expense, because it was believed to be an improvement on existing practice. We have still to keep up our old taps and dies for repair work, but no mechanic has deemed the expenditure involved in the change other than judicious.

To enable you at your leisure to consider the value of our inch unit as compared with the French system, I have added to this paper (Appendix B) a list of some of the prominent metric screw systems as compared with the United States standard and the Whitworth.

Recognizing the advantages offered by the decimal system in money, we accept the dollar and cents in preference to the pound sterling of England. We now have in use, in land surveying in the country, the chain and its decimal division. In city measurements the foot and its decimal division is also used, and in mechanics we have the inch as our unit, with its division into one-hundredths for calculation, and into vulgar fractions where its written expression is rendered plainer thereby. I have in this paper made no attempt to discuss the merits of the metric system as carried out in all its perfection, through measures of distance, surface, solidity, and weight. This has been considered by abler men than I am. My object has been to present to you the cost involved in the change, and to show that something more than want of education strengthens the hands of Englishmen and Americans in resisting any change in their methods of measurement. By the law of our land, those of our citizens who choose to use the metric system can do so, and their so doing will meet all requirements of the law; but the standard of the land is, for our purposes, the inch, and I for one should be sorry to see it abolished.

If, as I am informed, some of our schools of science see fit to make their method of teaching dependent on the metre and its divisions, to the exclusion of the ordinary nomenclature of the land, their wisdom may well be questioned. We need educated engineers, but we need them educated in our mode of thought. The universities of the land are awake to the need of scientific education, and our sons are sent to them that they may learn what will be of the most use to them in active life. We wish them to learn the languages of other leading lands, but we insist that they shall know their own language. We would have them read the scientific languages also, but if for good reasons we choose to retain our technicalities, deeming them more convenient for our use, we also insist that they shall know how to use them in our business relations.

Impressed, as I am, with the insurmountable difficulties in the

way of a change in our unit of measurement, even if that chang- were desirable, I can not kelp thinking that, if the hypothetical New Zealander, when he has done contemplating the ruins of St. Pauls from the sole remaining vestige of London bridge, in the far-off distance of the future, shall seek from the ruins of a mighty city to learn the nature of a nation's greatness, and shall measure its length and its breadth, as did Professor Piazzi-Smyth the Pyramids, he will find its unit of measurement to have been the inch.

APPENDIX A.

Millimetres...	Inch	Inch	Millimetres...	Millimetres...	Inch	Inch.	Millimetres...	Inches.........	Millimetres...
1	.03937			13	.51182			2	50.76
		1/16	1.58	14	.5512				
2	.07874					9/16	14.26	3	76.14
3	.11811			15	.59056				
		1/8	3.17			5/8	15.85	4	101.52
4	.15748			16	.62994				
		3/16	4.73	17	.66931			5	126.9
5	.19685					11/16	17.43		
6	.23622			18	.70868			6	152.28
		1/4	6.34	19	.74805				
7	.2756					3/4	19.02	7	177.66
		5/16	7.92	20	.78742				
8	.31497					13/16	20.60	8	203.44
9	.35434			21	.82679				
		3/8	9.51	22	.86616			9	228.42
10	.39371					7/8	22.19		
11	.43308			23	.90553			10	253.80
		7/16	11.09			15/16	23.77		
12	.47245			24	.9449			11	279.18
		1/2	12.68	25	.98424				
						1	25.38	12	304.56

Centimetres...	Metre.........	Inches... ....
1	.01	.39371
2	.02	.78742
3	.03	1.18113
4	.04	1.5748
5	.05	1.9685
6	.06	2.3622
7	.07	2.756
8	.08	3.1497
9	.09	3.5434

Decimetre...	Metre	Inches ....
1	.1	3.9371
2	.2	7.8742
3	.3	11.8113
4	.4	15.7484
5	.5	19,6855
6	.6	23,6226
7	.7	27,5596
8	.8	31,4976
9	.9	35,4339

1 metre=39.371 in.

APPENDIX B.—Comparison of Screw Threads in use.

	FRANCE.							ENGLAND.				AMERICA.			
	PITCH IN MILLIMETRES.							WHITWORTH.				UNITED STATES STANDARD.			
				Vignole d'Armengaud.		Ducommun.									
Diameter in Millimetres	French Railroads	Denis Poulot	Bodmer	Diameter	Pitch	Diameter	Pitch	Diameter in Inches	Diameter in Millimetres	Pitch in Millimetres	No. of threads per inch	Diameter in Inches	Diameter in Millimetres	Pitch in Millimetres	No. of threads per inch
3	...	...	0.5	...	...	3	0.5	...	...	...	...	...	...	...	...
4	...	...	0.5	...	...	4	0.75	...	...	...	...	...	...	...	...
5	...	...	0.83	5	1.4	5	0.75	$\frac{3}{16}$	4.7	1.058	24	...	...	...	...
6	...	...	0.83	...	...	6	1	$\frac{1}{4}$	6.4	1.27	20	$\frac{1}{4}$	6.4	1.27	20
7	...	1.5	1	...	...	7	1.25	...	...	...	...	...	...	...	...
8	1.5	1.5	1	7.5	1.6	8	1.25	$\frac{5}{16}$	7.9	1.41	18	$\frac{5}{16}$	7.9	1.41	18
9	...	1.5	1.25	...	...	9	1.5	...	...	...	...	...	...	...	...
10	1.5	1.5	1.25	10	1.8	10	1.5	$\frac{3}{8}$	9.5	1.585	16	$\frac{3}{8}$	9.5	1.555	16
12	1.5	1.75	1.47	...	...	12	1.75	$\frac{7}{16}$	10.1	1.815	14	$\frac{7}{16}$	11.1	1.815	14
14	...	1.75	1.73	12.5	2	...	...	$\frac{1}{2}$	12.7	2.12	12	$\frac{1}{2}$	12.7	1.95	14
15	2	2	1.73	15	2.2	15	2	$\frac{5}{8}$	15.9	2.309	11	$\frac{9}{16}$	14.26	2.12	12
18	2	2	2	17.5	2.4	18	2.5	...	...	...	...	$\frac{5}{8}$	15.6	2.309	11
20	2	2.5	2.5	20	2.6	20	2.5	$\frac{3}{4}$	19.1	2.54	10	$\frac{3}{4}$	19.1	2.54	10
23	2.5	2.5	...	22.5	2.8	23	3	$\frac{7}{8}$	22.2	2.82	9	$\frac{7}{8}$	22.1	2.82	9
24	...	...	2.78	...	...	...	...	...	...	...	...	...	...	...	...

APPENDIX B.—Comparison of Screw Threads in use.—Continued.

	FRANCE.							ENGLAND.				AMERICA.			
	PITCH IN MILLIMETRES.							WHITWORTH.				UNITED STATES STANDARD.			
				Vignole d'Armengaud.		Ducommun.									
Diameter in Millimetres	French Railroads	Denis Poulot	Bodmer	Diameter	Pitch	Diameter	Pitch	Diameter in Inches	Diameter in Millimetres.	Pitch in Millimetres	No. of threads per inch	Diameter in Inches	Diameter in Millimetres.	Pitch in Millimetres	No. of threads per inch
25	3	3		25	3	25	3	1	25.4	3.175	8	1	25.4	3.175	8
26			2.78												
28	3	3	3.125			28	3	$1\frac{1}{8}$	28.6	3.629	7	$1\frac{1}{8}$	28.6	3.629	7
30	3	3	3.125	30	3.4	30	3.5								
32	3	3.5	3.58			32	3.5	$1\frac{1}{4}$	31.8	3.629	7	$1\frac{1}{4}$	31.8	3.629	7
34			3.58												
35	3.5	4		35	3.8	35	4	$1\frac{3}{8}$	34.9	4.225	6	$1\frac{3}{8}$	34.9	4.225	6
37						37	4								
38	3.5	4	4.18					$1\frac{1}{2}$	38.1	4.225	6	$1\frac{1}{2}$	38.1	4.225	6
40	4	4.5		40	4.2	40	4								
42			4.18			42	4.5	$1\frac{5}{8}$	41.3	5.08	5	$1\frac{5}{8}$	41.3	4.61	$5\frac{1}{2}$
45				45	4.6	45	4.5	$1\frac{3}{4}$	44.5	5.08	5	$1\frac{3}{4}$	44.5	5.08	5
46			5												
47						47	5	$1\frac{7}{8}$	47.6	5.65	$4\frac{1}{2}$	$1\frac{7}{8}$	47.6	5.08	5
50			5	50	5	50	5	2	50.8	5.65	$4\frac{1}{2}$	2	50.8	5.65	$4\frac{1}{2}$

THE PRESIDENT—What action will you take upon the paper read by Mr. ellers?

Mr. ELLIOTT, Ohio & Mississippi Railroad—I move the acceptance of it, nd that it be embodied in our report.

Mr. HAYES, Illinois Central Railroad—I would suggest an amendment, iat we te nder Mr. Sellers a vote of thanks for the able paper he has read.

The motion, as amended, was adopted.

THE PRESIDENT—The next business in order will be the report of your ommittee on the subjects for consideration during the ensuing year.

The Chairman, Mr. Forney, then read the following report:

Report of Committee on Subjects for Next Meeting.

MR. PRESIDENT AND GENTLEMEN—The Committee appointed to lect subjects for discussion at the next annual meeting, respectfully .ggest the following:

First. The Best Material, Construction, Operation, and Management of Locomotive Boilers.

Second. Purification of Feed-water. What methods, up to this ne, have been most approved for the improvement of feed-water r chemical and mechanical means, and for the prevention of inustation.

Third. Locomotive Tests. This Committee to request members make experimental tests to show the performance of locomotives, id to report the results to this Association.

Fourth. Locomotive Construction. This Committee to report, as r as possible, all new methods of construction which have been lopted by members during the past and coming year.

Fifth. The Best System of *Signals* for Operating *Railroad Trains.* o include Train-head Signals; Train, Tail, and Side Signals; Road · Station-switch Signals and Appliances for Indicating the Speed : Trains.

Sixth. Locomotive and Tender Wheels. This Committee to report breakages of wheels and tires, removals of tires and cause of reakage or removal, and to report on the different methods of conruction and manufacturing of various kinds of engine and tender heels.

Seventh. Construction and Improvement of Continuous Train Brakes during the Ensuing Year, and their Application to Cars and Locomotives.

Eighth. Lubricants for Locomotives.

THE PRESIDENT—You have heard read the report of the Committee on Subjects. What action will you take upon it?

Mr. HAYES, Illinois Central Railroad—I move that it be received, and at a proper time the Committees appointed on the different subjects.

Adopted.

Mr. Sprague, of Pittsburg—I would like to inquire when is the proper time to suggest any further subjects for consideration; now, or at some future time?

THE PRESIDENT—It is proper to receive the report first.

The report was then adopted.

THE PRESIDENT—The next business in order will be the report of your Committee on Valves and Valve Gearing.

The Secretary then read the report.

Report on Valves and Valve Gear.

To the American Railway Master Mechanics' Association:

GENTLEMEN—Your Committee forwarded to the members of the Association a circular embracing the following questions, with a further request for general information on the subjects designated:

1. Have you had any experience with balanced slide valves? If so, please state fully what advantages they possess over the ordinary valve.

2. Have you had any experience in changing the size of the ports upon the same cylinder, in order to determine in practice what are the proper proportions of the size of ports to the size of cylinders?

3. What, in your experience, has given the best results as to the amount of inside and outside lap?

4. Please give the length of time, and number of miles run, and the condition of the valve seat on the cylinder with the ordinary valve, and also the same with the balanced valve.

5. In your opinion would it be advantageous to shorten the ports nd widen the bridges so as to increase the wearing surface on the alve seat of the cylinder?

6. Please send a correct drawing of the balanced valve you have used, and the name of the patentee.

It is the regret of the Committee that the replies to the above circular have been neither numerous, nor, for the most part, very full—fourteen members only having responded.

Thomas M. Hayes, of the Flint and Pere Marquette Railroad, says:

"I have had some experience with balanced slide valves. They do not possess advantages enough to pay for adopting them. I have had no experience in changing the size of ports. My practice as to lap, is $\frac{7}{8}$ of an inch outside lap, and line and line inside. This is with a $4\frac{1}{2}$ inch travel. I do not think it would be advantageous to shorten the ports and widen the bridges as specified. The balanced valve with which I experimented, is the Richardson's patent, of which I can not at present send the drawing. I run it about two months, or four thousand nine hundred and sixty miles. The valve seats were found to be in good condition, but the valves blowed badly past the strips in the top, and I had to take them out. The common slide valve run the same time, but about six thousand miles, and the seats were in equally good condition."

George Richards, of the Boston & Providence Railroad, writes:

"I have had no experience with balanced valves, or at least I have not used one worth adopting, and I hear that some that promised well last year do not look as well now. As to the size of ports I think we have been inclined to make them larger than necessary. I have closed up some ports which were very large, and found no loss in the power or speed of the machine, and the seats were easier cared for."

D. S. Weaver, of the Eastern Kentucky Railroad, has had no experience either with the balanced valve, or with changing the size of the ports. He thinks it would be advantageous, however, to increase the width of bridges, making at the same time a proportionate re-

duction in the length of ports. He thinks it unnecessary to put any more area into the face of the valves, his idea being somewhat analogous to that embodied in Mr. Elliott's end-bearing valve. Mr. Weaver further looks to the chilling of valve seats and faces as the first real and practical step toward prolonging the wear and reducing the consumption of fuel, and thinks that thereby the necessity for a balanced valve would be obviated. The maximum mileage of the common slide valve he is now using was forty-one thousand eight hundred miles. He gives his valves $\frac{3}{4}$ inch outside and $\frac{1}{8}$ inch inside lap.

William Fuller, of the Atlantic & Great Western Railroad, would not recommend the shortening of ports and widening of bridges. He finds the wear of the ordinary slide valve to be $\frac{1}{16}$ of an inch in a run of twelve months, or three thousand miles. The ports giving best results are in the proportion of 1 to 12 to the piston area for freight, and 1 to $11\frac{17}{100}$ for passenger engines. He is using $\frac{1}{16}$ of an inch inside and $\frac{3}{4}$ inch outside lap for freight engines, and from $\frac{7}{8}$ to 1 inch outside, line and line inside for passenger engines, and ports 16 inches by $1\frac{1}{8}$ inch. He has had no experience with balanced valves.

J. K. Taylor, of the Old Colony Railroad, writes:

"I have tried five kinds of balanced valves. All of them, in my opinion, are nearly worthless. I have only one kind running now; those are the Nesbitt valve, on two engines only. These I do not think a success, by any means, not much better than the old kind of a slide valve, as it is almost impossible to keep them from blowing any great length of time. I do not think the exhaust is as good with the Nesbitt valve as it is with the old style flat valve, but find the links and other working parts of the valve gear much more durable where we use a balanced valve. I think the area of the steam-port of a good smart working engine should be to the area of the cylinder as 1 to 15, and the exhaust port should be about 1 to 7. My experience has led me to believe this to be a good proportion for a freight engine. I give lap as follows: Passenger engines $\frac{7}{8}$ of an inch outside and $\frac{1}{16}$ of an inch inside; and freight engines $\frac{3}{4}$ of an inch out-

side and $\frac{3}{32}$ of an inch inside. I think it would be an advantage to some kinds of engines—for instance the Rogers—to shorten the ports and widen the bridges."

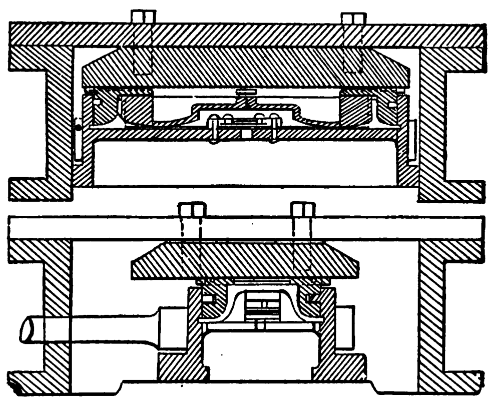
James M. Boon, of the Pittsburg, Ft. Wayne & Chicago Railroad, says:

"I have had but little experience with balanced valves, which I reported fully to the Committee last year." The report referred to was to the effect that a set of roller valves tried for six months proved of no advantage whatever, and a couple of sets of balanced valves on fast engines leaked so badly as to be abandoned after a run of two thousand miles. Mr. Boon further says: "I have made no experiments in changing the size of ports. I do not think there is any advantage in inside lap, but, on the contrary, I have always found it an advantage to cut it out. The amount of outside lap is governed to a great extent by the work the engine has to do. If, on a road with very heavy grades and trains, I would use $\frac{3}{4}$ inch lap or less; on a level road would use $\frac{7}{8}$ of an inch. On this road we are using $\frac{7}{8}$ of an inch on freight and 1 inch on passenger engines, with the valves cut line and line inside. There is also a considerable saving of fuel with a long lap valve. I do not think there would be any advantage in shortening the ports and widening the bridges, the valve would have to be made to suit, and the area exposed to pressure of the steam increased. I do not believe it is so much bearing surface we want as to reduce the area, and hence the pressure on the valve. I have no balanced valve now in use, and believe what is saved in reduced pressure in this class of valve is lost by increase of repairs."

W. A. Robinson, of the Great Western Railroad, Canada, believes the balanced valves to possess advantages, and refers to report of last Convention. His experience shows $\frac{7}{8}$ of an inch to be the lap for a travel of $4\frac{5}{8}$ inches. He thinks, with reference to shortening ports, that extremes in either direction are disadvantageous. He has adopted, for all train engines, steam ports 15 inches by $1\frac{1}{4}$ inch, and exhaust 15 inches by $2\frac{3}{4}$ inches, with bridges $\frac{7}{8}$ of an inch thick, which give satisfactory results.

John Thompson, of the Eastern Railroad, has used Adams', Saults', and several other balanced and roller valves. None except Adams' possessed any advantages over the ordinary slide valve. Reduced wear of valves, seats, and valve gear, and ease in handling the reverse lever under steam, were points of improvement realized in the use of this valve. With the ordinary slide valve the engine runs fifteen months, or forty-five thousand miles, without refacing. With balanced valves the run is eighteen months, or sixty-six thousand miles, and the various parts in better condition than with the plain slide valve. He has not experimented in altering the size of ports, but he understands that experiments upon shortening ports have been made with favorable results. With reference to lap, the best results obtained from practice are with $\frac{1}{16}$ of an inch inside and $\frac{7}{8}$ of an inch outside lap.

Figure No. 1—HUTCHINSON'S BALANCED VALVE.



C. L. Eastman, Concord Railroad, sends a tracing of a balanced valve patented by Charles H. Hutchinson (*Figure No.* 1), and states that upon ten locomotives fitted with it he has found a marked diminution of friction and wear of valve seat and gear. It has proved itself simple in construction, cheap, durable, and is in fine the best valve which he has used.

The Superintendent of Motive Power and Machinery of the Terre Haute & Indianapolis Railroad, writes very satisfactory as follows:

"I have a limited experience with balanced valves. I tried, first,

bolting two shallow cylinders, 7 inches in diameter, to the back of an ordinary slide valve, with circular grooves cut in their upper edges, into which packing rings, breaking joints on the Dunbar plan, were placed, and kept up to the planed steam chest cover by the steam pressure, assisted by light spiral springs. The valves worked freely with steam, but occasionally at starting would blow badly, caused probably by the force of the exhaust striking the top of the chamber, or by the compression in the steam ports. More recently I have tried a modification of this plan, and core two circular holes through the valve and allow the exhaust to strike the lid of the steam chest. I send you a sketch of the valve which will show its construction. The engine ran eight months, or twenty-three thousand four hundred and thirty-three miles before there was any perceptible blow, and the reverse lever could be worked easily with any amount of pressure.

"At that period there was a complaint made by the engineer that the lever worked harder, and that the engine blowed some. The lid was taken off and the rings were found worn unequally on the face, and the lid worn considerably where the rings bore, and quite a shoulder had been made at the termination of the valve stroke generally used by the engineer. New rings were put in, and the lid planed off, and the engine is now running. I see no benefit from the valve in the performance of the engine, and the engineer thinks she is not so smart as she was with her old valves. As the engine burned wood before the valves were put in, and now burns coal, I can make no comparison as to the consumption of fuel. There is no question but what there is a saving of wear in the links and the valve seats, but I am not prepared yet to recommend the use of this or other similar balanced valves from my experience with this. A Mr. Bisbee, of Indianapolis (*Figure No.* 2), claims a patent on this, or a similar form of valve.

"I will also state that I have used a long valve with ports running through the valve, patented by Henry Elliott, of the Ohio & Mississippi Railroad, and find considerable advantage in durability of valve and valve seat surface from its use. Freight engine 34 of this line has one cylinder of unusually soft iron, and it was found necessary to face off seats and valves about once in six weeks, or

Figure No. 2—BISBEE'S BALANCED VALVES.

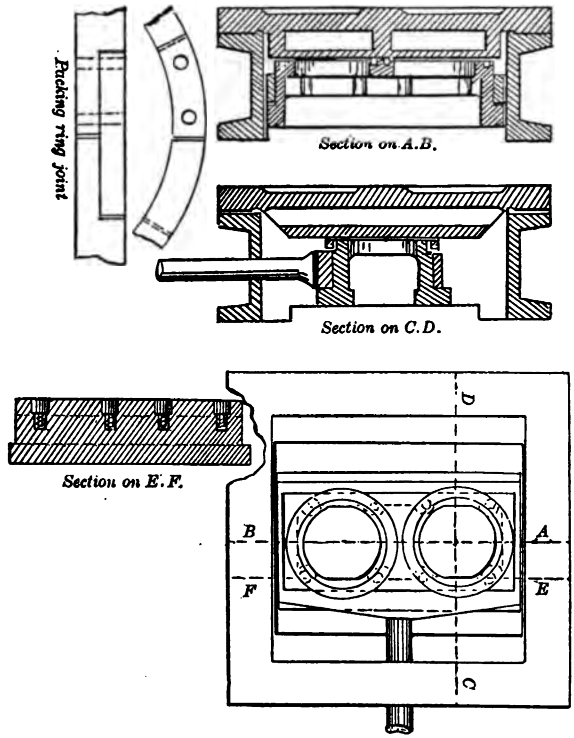
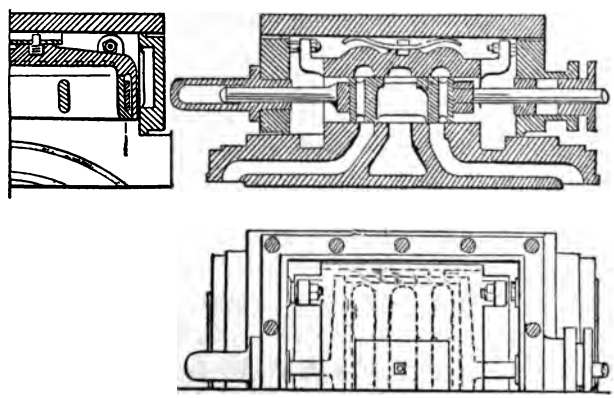


Figure No. 3—GLEASON'S BALANCED VALVE.



after running five thousand one hundred miles. I put the Elliott valve in and run the engine nine months, or thirty thousand miles, before the seats required facing. I have the valve in three other engines, and am awaiting the result with interest.

"I have three Rogers' freight engines, 16 by 24 inches, with 5 feet drivers, and steam ports 15 by $1\frac{1}{4}$ inches, and two engines subsequently built by the same maker, with same cylinder and wheel but somewhat heavier, with steam ports $13\frac{1}{16}$ by $1\frac{1}{8}$ inches, which are daily drawing longer trains and with the same proportionate consumption of fuel, and are considered as smart as the first engines. I usually give an outside lap of $\frac{7}{8}$ of an inch on a valve having $4\frac{3}{4}$ inches travel, and allow no inside lap. I use the same dimensions on freight and passenger engines. The ordinary valves and seats on our coal burning freight engines require facing on an average once in four months, or after running thirteen thousand two hundred and twenty miles. Coal burning passenger engines once in six months, or after running nineteen thousand three hundred and four miles.

"I think it would be no detriment to reduce the present dimensions of steam and exhaust ports, especially where the former is double the area of the exhaust nozzle, as is not unfrequently the case, and also to increase the thickness of the bridge where it can be done without increasing the travel of the valve."

Wm. S. Hudson, of the Rogers Locomotive and Machine Works, incloses a draft of a balanced valve (*Figure No.* 3), patented August 29, 1854, by John Gleason, of Northfield, Vermont, and says they are acquainted with many different kinds of balanced valves that have been in use, and the causes which led to their abandonment, and thinks this valve as shown would be likely to succeed as well as any, and better than most of them. The valve as first invented differed from the tracing in this respect. The saddle plate was held by bolts to the steam chest cover, the bolts being used to adjust the saddle so as to admit of the valve moving freely between it and the valve seat. Poppet valves were used to afford relief when the engine was reversed.

He built a locomotive for the Buffalo & Erie Railroad in January, 1856, in which it was used for some time, but abandoned on account of the trouble in keeping the saddle plate properly adjusted. The

modification shown in the tracing consists in supporting the saddle by the face of the valve seat, the side supports being cast on the saddle, as is the practice in valves for steam hammers. The screws for holding the saddle in position endwise would require to be adjusted so as to allow of the valve and saddle rising when required. It is further to be noticed that this valve has another peculiarity, viz.: double width of both steam and exhaust ports, as steam is taken through the valve as well as outside at the same time. The tracing is made so that the lead is confined to the lower edge of the valve, so that the piston is at or past the center before steam is taken through the valve. This is done to avoid too great shock by too sudden admission of steam. He is not aware of the patent having been renewed.

With regard to the best results to be obtained from any definite amount of outside and inside lap, it is difficult to give a very definite opinion, as the results vary with every different amount of travel of valve, as well as with the different circumstances of load, grade, speed, etc.

Without replying at large to the circular of the Committee, Henry Elliott, of the Ohio & Mississippi Railroad, sends the following letter:

"I have nothing to say on the subject of balanced slide valves, not having had any experience with them on locomotives. I wish, however, to call your attention to, and give you a report of, the working of my End Bearing Slide Valve (not balanced valve as erroneously given over the cut of it in last year's Report). By referring to my letter to Mr. Fry, published in last year's Report, you will see what I claim for this valve, all of which claims I consider fully confirmed, so far as another year's experience goes. I have not yet had one valve to face, and from the appearance of valves and cylinder seats that have been running twenty-one months, my impression is they will not require for a long time to be refaced, as they are now, to all appearance, in the same condition that they were after having run one month. I give you below the mileage of three engines that have run longest with these valves, and also the average run of the same engines with the old short valve between refacing of valves.

"Baldwin freight engine No. 122 ran with End Bearing Valve fifty-four thousand three hundred and thirty-two miles; average run with old valve eighteen thousand two hundred miles. Grant passenger engine No. 58 ran with End Bearing Valve seventy thousand three hundred and thirty-seven miles; average run with old valve fifteen thousand seven hundred and fifty miles. Passenger engine No. 63, built by the Ohio & Mississippi Railroad, ran with End Bearing Valve sixty thousand one hundred and sixty miles; average run with old valve nine thousand seven hundred and fifty miles. We have besides these three engines thirty-one other engines running with these valves, all giving the same results. I would also state that the longer I run these valves the more I feel satisfied that there is a great saving in wear of valve gear. I account for this saving by the fact that this valve moves with a much steadier motion than does the old valve.

"As the number of these valves in our engines have been increased, the saving of fuel has been very evident to us, but this point is clear to all mechanics who understand the operation of the slide valve. For, if we have a valve that will maintain itself continually in performing its proper functions without blowing or otherwise wasting steam, there must be a saving in fuel over a valve that will only run five or six months and then have to be reseated or refaced, and this is about as long as engines built at the present day will run in regular passenger and freight service and burning coal. I could give you the experience of others that have this valve in use, but I prefer that they should speak for themselves. If you have not seen a model of this valve I think the cut as given in last year's Report makes it sufficiently understood."

The Master Mechanics of the Morris & Essex, and of the Lake Shore & Michigan Southern Railroads, have neither of them had any experience with balanced valves, and hence offer no information. The former gives a lap of $\frac{3}{4}$ of an inch outside and $\frac{1}{16}$ of an inch inside, and the latter gives $\frac{7}{8}$ of an inch outside to $\frac{1}{16}$ of an inch inside. They both concur in the opinion that the size of the ports is excessive as compared with the area of the throttle and cylinder, and recommend their reduction with a proportionate widening of

bridges, unless a good balanced valve can be found cheap and durable.

As your Committee interprets its duties, it submits the foregoing testimony for discussion in open session, refraining from the intrusion of personal opinion or comment thereon. For the succinct presentation of the points in question we recapitulate:

Of the fourteen members answering to the circular, four report in favor of balanced valves and six against, while nearly all agree that there is a reduction in wear of seats and gear and increased ease in handling. The grounds of objection are, liability to blowing and difficulty of keeping in repair. The mileage of the balanced valve, where comparisons have been instituted, is considerably in its favor as against the flat valve. Seven replies are in favor of decreasing the size of ports from their experience, and two offer simply an opinion against reduction.

The practice with lap is somewhat varied. Outside, two use 1 inch, eight use $\frac{7}{8}$ of an inch, and four use $\frac{3}{4}$ of an inch, the longer lap being upon the quicker moving engine. Inside, one gives $\frac{1}{8}$ of an inch, one gives $\frac{3}{32}$ of an inch, five give $\frac{1}{16}$ of an inch, and five cut the valve line and line; the general practice standing in favor of inside lap to cushion on the pistons of quick moving passenger engines.

If the report of your Committee is meagre, they still beg leave respectfully to submit it, relying upon the consciences of delinquent members to acquit them of blame for its shortcomings.

J. I. KINSEY, *Lehigh Valley*,
J. THOMPSON, *Eastern Railroad, Mass.*,
G. H. TIER, *Lake Shore & Mich. Southern*, } *Committee.*

On motion the report was received.

THE PRESIDENT—Gentlemen, the subject of the report of the Committee on Valves and Valve Gearing, is now open for discussion.

Mr. HUDSON, Rogers Locomotive Works—Mr. President, the subject of the comparative sizes of valve openings is a very important subject, and one upon which I know a great many authorities disagree. Experiments have been tried—and I remember some years ago the United States Government tried some experiments in New York at the Novelty Steam Engine Works—and I understood that they tried the effect of diminishing the port in order to ascertain how far the ports could be diminished without impairing the effi-

ciency of the engine, and they discovered that the ports could be diminished without material detriment to the working of the engine. They then tried what the effect of diminishing the passages in the same ratio would have, and they found that they could not do anything; in other words, the diminishing of the passages entirely destroyed the efficiency of the whole thing. Therefore, while you may make the ports operate diminished half their size, you must not diminish the passages at the same time; if you do you will obtain no benefit, but rather lose. I think that is a very important point; and I know from my own experience the effect to be as I have indicated; and while I am ready and willing to make the ports as small as any one may want, I want them to let me make the passages as I wish; then I will guarantee the results; but any one who insists upon the passages being reduced as the ports are reduced, will certainly be disappointed in the result.

Mr. Eddy, Boston & Albany Railroad—Mr. President, when I came here I did not mean to trespass much upon the time of this Association, and I do not intend to now, for I suppose it is not necessary for me to say much on this valve question, for all before me know before I speak very near what I would say in the main. In relation to what the last gentleman has said about increasing or diminishing the size of the openings, I would simply say what I do. For my freight engines I make the passage way ten inches by one and a quarter inch. I keep the opening of the port the same, ten inches by one and a quarter inch; for passenger engines I make the ports twelve inches long in the room of ten inches, leaving the passage way the same in each instance, without saying whether it is right or wrong. All you who have been our way, and taken the pains to see how our engines do their business, can tell as well as I can whether it is right or not. I can simply say that they do what is given them very well. My opinion is that a passage way ten inches by an inch and a quarter, is sufficient for a cylinder not more than eighteen inches by twenty-six inches.

Mr. Hudson, Rogers Locomotive Works—Mr. President, the reason I believe why passages need to be large, is not for the purpose of getting the steam in, for we all know we can get it in. The proportion of area of opening in the throttle valve is usually very small as compared with the size of the steam pipes, but there is no difficulty in getting steam through it unless we diminish the pipes in the same ratio, and then there is great difficulty. The area of these passages, then, is wanted for the increase of volume of steam at the time of exhausting. The moment you relieve it from the pressure the volume is increased, and it wants more room to get out; and that is the reason why large passages are required. Now, with regard to balance valves, I can not say that I am favorably impressed. All the information I have been able to get with regard to them has not been very satisfactory. I was at the North London Railway last summer, and I saw some seven or eight different kinds of balance valves which they had tried, and they kept

an accurate account of the results in the performance of engines with the balance valve, and they all, so far as consumption of fuel was concerned, gave inferior results as compared with the ordinary slide valve; and so far as wear and tear was concerned, there were very few of them any better than the ordinary valve, and they had taken them all out and were using the ordinary valve.

Mr. FARIES, Atchison, Topeka, & Santa Fe Railroad—I would like to know what the throw is with 50 or 25 per cent. cut-off; I would like to know the expansion it would give to that length of port. I think it is proper that we should understand just how that valve works with this short port.

Mr. EDDY, Boston & Albany Railroad—The throw that I commonly give is five inches. I have them five and three-quarter inches, but that is the maximum in regard to the fractional part of the throw. I do not know that I can give that. The gentlemen may, perhaps, be aware that we have what is called a hard road. Our road is crooked, and the grades are heavy, being all the way from a level up to eighty-two feet to the mile. We have one grade that is eighty-two feet to the mile for twelve miles. Our engines have to perform all sorts of service, from hauling heavy freight trains at a slow rate of speed to heavy passenger trains at a high rate of speed. We have had engines from quite a large number of builders, and as you are all aware, some of them make long ports, and we have found that invariably those engines do not come up to what they should be in comparison with engines with a shorter port. I have no theory to offer, Mr. President, in this case, only actual experience, which, I suppose, is about as good as most anything. I give, for my passenger engines, about seven-eighths of an inch lap, and cut them over about a sixteenth of an inch, so that they are cut over the sixteenth of an inch on the inside, with about seven-eighths of an inch lap on the outside; for freight engines about the same inside, and three-fourths of an inch lap outside.

Mr. JACKMAN, Chicago, Alton & St. Louis Railroad—Mr. President, there is something that I want to say on this subject, and I hope the members of the Convention will bear with me if I should take a little more time than they think I ought to. I believe like this. Our committees are appointed, and they serve us to the best of their ability in every possible way. They make us reports that cost them a good deal of labor; and sometimes I find that some of our papers, devoted particularly to railroad science, say too much time is spent in the discussion of subjects—"You should not discuss subjects. Do your business, and then go home. When your reports come in, accept them, and have them printed, and get your business done in that way." Now, I do not believe, for one, that that is the business of the Convention; and I do not believe that that subserves the interests of the Master Mechanics, or of the railroads they represent. No matter how full the reports may be, and how much they embrace, what we want to get at is the ex-

perience of every man who has had practice in the subjects brought up. So far as balance valves are concerned, I have had a little practice, or a little experience, during the year and a half past, or perhaps longer than that, with one or two engines, and I would like to relate that experience. The first that we experimented with were of the Adams pattern or patent, which all of you know very well. We had them on two engines doing switch service nearly three years, and the results have been very good indeed. They have not been very costly to maintain. I took them up occasionally, perhaps once a year, or a little more than that, and found that the seats worked very good, and the valves also, and the upper surface of the steam chest, where the top part works, wears very smooth, and it does not require very much work to fix them, while the men who handle these engines say that they handle better and easier than with the other valves. They like them. We have experienced no difficulty with them. On the strength of this experience I put the same valve on another engine that is now running a passenger train, and has been with that valve for the last six or eight months or more. The same success has attended that. It has worked well. Mr. Elliott, of the Ohio & Mississippi Railroad, desired me to test his valve, which I have done. I think we have six engines running]wtth the Elliott valve in use, but so far as its operations are concerned, and how much saving in the facing of the valve seats may be made, I can not tell as yet, having used it only eight or nine months. We have not taken up one to face it in the whole time. I put two of those valves into an engine that was running regularly on the road, and sent the engine out without saying anything to the man running the engine about my having changed the old-fashioned valve for the Elliott valve; and in running the engine he never discovered the difference in the working of the two; and after he had run her a long time I told him. I do not know as they handle any easier with that valve than with the other, but they give us a more extended surface of valve, and, as you know, with the same friction on a more extended surface, the surface must wear longer. Then, again, in letting steam in, the question comes up as to whether we need all the length and breadth of port in order to work the engine successfully. To determine that point we drilled an inch or an inch and an eighth holes, and as many as we could in the length of the valves, leaving three-eighths of an inch space between the holes. I sometimes got in ten holes, and in some valves I got in eleven one and an eighth inch holes, and that is all the room for the increase of steam that we have, which, of course, is considerably less than the port itself would be if we used the old-fashioned valve; on the other hand, you will bear in mind that for the exhaust we have exactly the same sized opening of port that we do in the old valve, and the lap on the inside is precisely the same as the old valve. Now, in our engines, I find that there is no difficulty in admitting the steam, even if you do not open more than half the port, you get steam enough in to work the engine; but the difficulty,

I contend, would be, if any, in narrowing up the ports, or in shortening them' to get rid of the steam from the cylinder after it had performed its service there; and I do not believe that we should find it useful in any way to diminish to any very great extent the ports and the passages, so far as getting rid of steam is concerned. The injection ports, or the openings made by the valve, may be made smaller, but the ejection port, I think, must be maintained about as large as we have been in the habit of using them, in order to ged rid of the steam easily and readily. There is another kind of valve that I have been trying. It is a valve gotten up by a man in California, called the Collier & Masterman valve. It is like this: you have placed on the top of the steam-chest cover a cylinder which is carried up some twelve or fourteen inches in height—that cylinder is pretty large—and inside of it there is another cylinder that rotates on trunnions, and in that cylinder there is a piston; the valve is connected by a link to this piston, the piston working in the upper or inside cylinder that rotates easily by means of trunnions. By using that piston you take off as much of the pressure from the valve as you give size to the cylinder, comparatively. I have fitted that on about ten engines which have been running for more than a year. Although there is some trouble sometimes in taking up, adjusting, fitting, and packing, as a general thing we have no great difficulty with it. In good condition it works nearly as well as the balance valve. I have ridden on the engine naving that valve, and have taken hold of the reverse lever and pulled it up between two notches, letting it stand there while running two or three miles without moving one way or the other—it would hold itself there. Then I could easily move the reverse lever backward and forward with one hand while the engine had full steam on. In order to get rid of the steam that may leak by the packing, one of these trunnions is drilled through and the steam passes by the packing into the cylinder through this trunnion. On the outside of the engine we put a little pipe, screwing it into that trunnion and putting packing around it; we then have a little gland that screws up on that, and on the outside of that gland we make a hole and put a little gas pipe in, bringing it down the side of the large cylinder, and then it is carried off to the front of the engine, one from each side. When we are first starting, sometimes, there will be a little leakage by that cylinder and the steam will blow out a little from the cylinder cock. The last time that I noticed one of those engines was the day before I came here. As one of our passenger trains went by the shop where I was standing, I watched carefully, and at that time, when the engine was running with full steam on, there was not a particle of steam that I could discover coming out from these pipes, and I looked particularly for that purpose. But, as you know, the working of this piston which is caused by the movement of the valve can be but very little—it does not move more than a quarter of an inch at most

the consequence is, as we use metallic packing there, that after a time it will wear a little groove in the inside of the cylinder, but we have all these difficulties of wear any how, and, in fact, I do not know of anything that we use about a locomotive continually that will not wear out after awhile and have to be replaced. Sometimes we have to take these cylinders out and rebore them and refit the packing, but notwithstanding all that I do not want the Convention to understand that these things will not wear out as long as they are continually in use, nor do I want the Convention to understand that we can use these balance valves without some cost in the first place in putting them on. We have had about ten or twelve engines running for a year with those valves, and have had no great trouble during the time. There are four of them running on passenger trains and the rest on freight, and I consider that they have been tolerably successful; the arrangements certainly relieve the valve of a good deal of pressure. That is all the experience I have had with the balance valves. I have one other engine with the balance valve that was built at the Schenectady Locomotive Works, where they put the balance valve on—but whose I do not know; but it is something like the Adams valve, and yet not like it, and I do not think so good as it, although the engineer was saying to me the other day that he wished I would put one on another engine he was running, because the one that had it on handled so easily. This valve that I speak of has an oblong top instead of a circular one like the Adams, and grooves cut with packing in, and that packing must join at each corner; these short pieces go in and these long pieces butt against them. I do not know whose patent it is; it was one that was put in at the Schenectady Locomotive Works for us to test. It has worked tolerably well. The engine has been away from the shop running on foreign service, you might say, almost all the time, and consequently I do not know the real merits of it. So far as the Adams valve or lapping valve is concerned it has worked well, although I can not tell its relative merits until we take the valves up to face them. The Collier & Masterman valve has given us good service and we have had no particular trouble with it. What I wish to say in regard to this matter is that whenever these reports come in, and whenever any one in the Convention can give us any light or experience upon the subject, I for one will most cheerfully sit and hear all that can be said, and I believe that is just exactly as the rest of you feel. We can not get at the real results except through the experience of those who have tried these things. Further, I am free to say to this Convention that I never have a single interest to subserve, and that there is nothing in the world that I want to urge upon you or have the Convention adopt. I simply desire them to find out the truth in all these matters, and to learn the best methods of practice for us all. I never have any other point to make; and if there is anything that I have tried I do not want the Convention to think that, because I have tried it or used it and continue to use it, it

is the best thing in the world. What I want them to know is the best possible practice so far as the operation of engines is concerned.

Mr. HAYES, Illinois Central Railroad—Mr. President, I would like to ask Mr. Jackman what the results are in the consumption of fuel with those balance valves as compared with the old slide valves?

Mr. JACKMAN, Chicago, Alton & St. Louis Railroad—I do not think there is three per cent. difference between them. I have noted them at different times; our fuel sheets show that those engines that have these balance valves on will run cheaper some months than they do the same months of the next year without; then, again, I find times when they do not run so cheap, and I have come to the conclusion that so far as fuel is concerned we can not count on more than three per cent. advantage, comparing them with the other engines that do equal service. The great saving, if saving at all, must be in the wear of valve gearing and the saving of facing on the valve. Now, those engines on which these balance valves were placed were very bad, so far as their valve seats were concerned; for instance, one of the first that I put the balance valve on cut down the valve seat on one side more than a quarter of an inch in one trip, from some cause that I never could explain, and that was one thing that induced me to try the balance valve; and since the adoption of the balance valve, not only on that engine but on the others, I think we have saved a good deal on the valve seats. It may be that the cost of putting the valve on and the cost of maintaining it has equalled what it would have cost otherwise; but it seems to me if those valve seats had continued to wear down as they were doing that we should have had to put new cylinders in long ago. I would not state that the consumption of fuel would be more than three per cent. in favor of the balance valve.

Mr. WHITE, Evansville & Crawfordsville Railroad—Mr. President, I will say that the balance valve that Mr. Jackman speaks of, with the cylinder arranged on top of the steam-chest cover, with the piston link connecting with the packing of the valve, I got up more than twenty-five years ago. There were others ahead of me, it seems, but I did not know it at the time. I made a drawing and submitted it to the inspection of Mr. McQueen, Superintendent of the Schenectady Locomotive Works, and we talked up the matter some time, and I was about to put it into operation and see what there was of it, and designed, if a good thing, to get it patented, but I learned very soon that a man at Worcester, Massachusetts, had got the same thing in operation on the Boston & Worcester Railroad. I think, from the fact that it was tried so long ago, that if there was really much merit in it, before this time it would have gone into general use; I have not heard anything about it, though, for a number of years, until now. Mr. Eddy, from that part of the country, probably could enlighten the Convention some on that subject, and probably give the Convention some reason why it did not go into general use.

Mr. JACKMAN, Chicago, Alton & St. Louis Railroad—Mr. President, I think I could enlighten the gentleman a little on that, having run the engine on the Boston & Worcester Railroad that had the valve in a good many years ago. I will state that there is this difference between the one we used and the one the gentleman refers to. The one that the gentleman refers to had a cylinder on top of the steam chest and piston working in that cylinder; the one that I refer to has a cylinder on top of the steam chest, and another cylinder within that rotating on two trunnions, and a piston working within that. That makes a difference between the two. The one on the Boston & Worcester road, I think, run about two years in all. I run the engine having it a good deal myself. There was one difficulty that I experienced with that. If you got the engine slipping it would lift the valve off its seat, lift it up out of the way entirely, and with a passenger train on the road I have had to stop and take off the steam-chest cover, and find where the valve was and put it down in its place, before I could go on. Otherwise that valve worked very well, with the exception that there was no provision made for the outlet of the steam that leaked by the packing of the valve, and we had to make the packing tight enough so that it could not leak; but if it did leak by enough to fill up the piston you would get no advantage of the valve there. After using that valve for about two years it was put on an engine called the "Bee," built by Wilworth, of South Boston, and after being used about two years was taken off.

Mr. WHITE, Evansville & Crawfordsville Railroad—I have to say that there was provision made in this arrangement of mine for the leakage of steam to pass off, so that did not interfere at all. In order to prevent the valve from lifting of course there would have to be a very nice adjustment, and not have the piston in the cylinder too large, otherwise it would lift. There is one very good thing about it, and that is the pressure is both ways in proportion, and it does not make any difference what the pressure in the steam chest is, the piston that raises the valve has its proportion of the pressure, and nothing will lift it off if the calculation is made right.

Mr. HUDSON, Rogers Locomotive Works—Mr. President, in regard to the lifting of the valve I apprehend it would depend a good deal upon whether the engine was reversed or not. I think if it lifted at all, that would be the time it would lift.

Mr. CHAPMAN, Cleveland & Pittsburg Railroad—I would state to the members of the Convention that I have recently put in a couple of valves, known as the Cummings valve, patented by Mr. Cummings, Master Mechanic of the Fort Wayne Railroad. I just took an ordinary valve and attached to each end of the valve a piece so as to shorten the ports, leaving the port in the cylinder the same as it was previous to shortening it—an inch and a half upon each end. I think we are going to get very good results from it. I have been able to enlarge the exhaust nozzles from four to four and a half

inches, and with, I think, a saving of fuel. I have recently put them in and am giving them a trial.

Mr. JACKMAN, Chicago, Alton & St. Louis Railroad—Mr. President, I want to state one thing that I forgot, if you will bear with me. We are using now, on three or four engines, another thing, and I want to state what it is so that every one can take advantage of it. We plane out a groove on the bearing surface of the valve of, say three-quarters of an inch in width, by almost the length of the valve, leaving the ends inside, then drill a little hole an eighth of an inch at each end down into that place and put the valve in. The first time I tried that was four months ago, I think. When the engine went out from the shop the man who took her out says, "she blows; I think we shall have to take these valves out and replace them." So I had a new set of valves, all fitted exactly every way, so as to just lift the cover off and replace those that we had grooved out with the others. After that I let the man run her on passenger trains. I put the air brake on her and put her into the hands of one of our very good runners, and run a passenger train between Bloomington and Chicago—one of our heavy trains—and after he had run her two or three times he came to me and said, "what in the world did you do to the valves of that engine? I used to run that engine before you put her in order on a freight, and she is an entirely different engine now; what did you do to the valves?" I said we did not do anything. "Why, certainly you have done something, for the engine don't handle as she used to handle." Then I told him just what we had done—that we had cut those grooves, and he said the engine handled a great deal better and a great deal easier. He had run the engine previously a great deal, and he discovered it without knowing anything about what had been done, so that I rather came to the conclusion that there was really some merit in those grooves. The only difficulty that there can be in it is this: At a certain point you may have what steam will blow through this one-eighth inch hole down into the steam port. That may be a disadvantage, but there is only a certain time during the stroke of the engine that that can take place. During the other part of the stroke you have what steam goes through, and from this three-quarters by fourteen or fifteen inches port, to lift up on the valve and take that much weight off the surface. I wanted to state this fact, and state what this engineer said about it. On the strength of that experience I have put the same thing into three or four engines since with pretty good results. It has not been more than four months since the experiment began, so I can not tell you what the result will be finally, but I simply suggested to the Convention. It is a simple, easy thing to try, and any one can try it, for I do not think there is any patent on it.

Mr. CHAPMAN, Cleveland & Pittsburg Railroad—Mr. Jackman, let me understand you. Do you cut that groove across the end of the valve?

Mr. JACKMAN, Chicago, Alton & St. Louis Railroad—No; we cut it lengthways. I cut some both ways, lengthways, and the other way; but I had to give that up. This cutting on the edge of the valve did not succeed. It is simply the groove on the longest way of the valve. Just groove it out the length of the port.

Mr. ELLIOTT, Ohio & Mississippi Railroad—Mr. President, I was very much pleased to hear Mr. Chapman make the statement that he did make, as it is simply a modification of the valve I am using. It is simply an end bearing valve, the bearing created on the receiving point, and it also shows, that as Mr. Cummings stated to me, we do not require near the amount of port to admit the steam, as he has narrowed up the port to nine inches, I think. The fifteen inch port in the cylinder is contracted on the valve by putting on this end bearing, so that he has only a nine inch port; still the engines do just as good work as they ever did. It is exactly what I claim as my improvement. The model that I saw Mr. Cummings have last year is altogether different, so far as the carrying out of the bearings is concerned, from the model that is in the patent office. It has a part extending out at the base, giving a steady movement to the valve; and that is what is accomplished by that plan, as adopted by Mr. Cummings.

Mr. HUDSON, Rogers Locomotive Works—Mr. President, some time about the year 1850, or from that to 1851, I was in charge of the motive power of the Buffalo & Rochester Railroad; had a couple of locomotives that were built at the Rogers Locomotive Works, with valves called the "V" valve, a valve in the shape of a great many throttle valves that had been used, taking steam on both sides. That was thought at that time to be an improvement, and was made for the purpose of diminishing the pressure and still maintain the size of the port. Well, the operation of it was not entirely satisfactory, and I put new valves into those engines with an extended face at each end covering up one-half the ports, and I found a decided improvement in the working, precisely as Mr. Chapman states. So long as I remained on the road those valves were in use, and continued in use for several years, working perfectly satisfactorily.

Mr. JEFFREY, Illinois Central Railroad—Mr. President, there is little doubt, in all probability, but what the area in the openings under the valve govern, to a great extent, the pressure upon the valve. I remember, about twelve years ago, Mr. Hayes made some experiments on the Illinois Central, the old road, by putting in the steam chest of one of the engines a plain plate, without any openings whatever in it, then fitting up to rest on that plate a plain block—that is, a block with a plain lower surface—no opening whatever in the block. By use of the spring-balance and lever the required power to move the block was ascertained. After several experiments without opening, we drilled a hole in the plate so that the block would slide over it; and we found as the area of these openings increased, the pressure on the block

increased, but not in proportion to the area of the openings—there seemed to be no direct proportion. Probably the reason of that is, that the surfaces were imperfect, although they were made as well as they could be with the mechanics we had. The experiment was continued there for two or three days, and the general conclusion was established that the pressure on the valve is dependent more on the opening under the valve than on the size of the valve itself. Of course we are all familiar with the experiment of putting two surface plates together, and we know that the pressure of the air holds them so tight that one will lift the other by the vacuum between the plates, and it was supposed by Mr. Hayes and some of the rest of us at the time that the surfaces being made well would exclude the steam, and the pressure would be due, not to the area of openings under the valve or under the block, but to the area of the block itself. That, however, as we found, was not the case. Some seven or eight years ago the question of the balance valves came up, and we made a square box valve without either top or bottom; it was a Rogers cylinder with a double exhaust, and we had no bridges inside the valve, and no top to it. It extended up to within a sixteenth of an inch of the steam-chest cover. The lower side of the cover was faced off carefully; then in the groove around the top of this square box was placed a square ring, if I may use the expression, on top right in this groove, and that was held up by four or six small spiral springs to the inside of the steam-chest cover, and the steam was also allowed to enter under this ring in order to hold it up there. The engine we had in use running some twenty months with it. During the twenty months we found no special difference in a mile-run per ton of coal. During the twenty months the seats of the valves were faced once, and the steam-chest cover on which the ring had a bearing was faced twice. In working on the road the reverse lever could be placed at any point whatever; it made no difference whether there was a notch on the quadrant or not, showing that there was scarcely any friction on the valve, but for the most of the time there was a slight blowing. If there was any opportunity for the steam to escape over the ring, or around under, between it and the groove which it fitted, it could go out the exhaust. There was always a slight blowing in consequence of this, and it may have been that that accounted for the engine not showing any better mileage per ton of coal. It stands to reason, of course, if the friction is lessened on the wearing parts, that it must take a little less fuel to move the machine; but then to offset that would be this continual blowing. After the experiment with that valve was tried, we took an ordinary valve—the Rogers valve, double exhaust—and placed on top of it a plate as long as we could put into the steam chest, bolted right down on top the valve. That plate was surfaced off very nicely. On the inside of the steam-chest cover was cast a groove; that is, there was a projection downward, and a groove cast or planed out carefully, and in that was fitted a ring so that the weight of it came down on top of the plate

at was on the valve, endeavoring in that way to make a tight joint there exclude pressure on top of the plate. We run a few trips, and the valve ndled tolerably easy, but at the end of that time we found it was just as 'd work to use the reverse lever as it was before we put it in. The next periment tried was by casting a valve, we will say, the full height of the m chest; then planed off the under side of the steam-chest cover, and planed off the top of the valve, so that it would come to within the sixourth or not more than a thirty-second of an inch from the under side of steam-chest cover, the idea being that the continual drawing of the steam n into the cylinder through the ports would not allow the pressure to aculate on top of the valve, there being such a slight space between the e and the under side of the cover. We found afterward that whenever engine was working heavily the valve handled more easily than is ordily the case; but when the engine was hooked up to six or seven inches, working still lighter, that the pressure was about the same as ordinarily. ng the last six or eight months a pair of valves have been put in simi- what Mr. Jackman described as the "Masterman valve." They were n one of our passenger engines. The cost of them was rather heavy to hey proved rather expensive; and we found they did not give satisfacresults, although the patentee claimed that there was some difficulty in d to the proportions of the valve and the way they were fitted up. They not seem satisfactory to him there. However, it showed no difference in uel used, and there was a continual blowing through these cylinders past packing through a couple of little pipes extending into the smoke box, so carry away the waste steam, but there wasn't any surface for the purof taking it off. We also tried two of Mr. Masterman's valves similar ose mentioned by Mr. White; just a cylinder goes on top of the steam- cover, but no oscillating cylinder inside, simple links extending down piston to the valve, requiring this piston to adjust itself into position the valve. From that we derive no benefit whatever. We had them r three or four trips, but had to take them out. We have also in use a of valves patented by Mr. Elliott, and the result so far is rather satisfac- Ordinarily, as we are all aware, valve seats were concave. With the valves on Mr. Elliott's plan, we found the seats were convex. The probty is that the valves spring down a little at the end, and so wear the seat tly convex. I believe that the valve has been shortened up a little; and perhaps, that will not occur any more. The engineer running that enreports that when she is working on the road hooked up to, say ten or ve inches, on freight, that he sees no difference between her action and of any other engine of her class; but when she is hooked down, full e, and starting up a train, she does not work quite so smart, as he terms loes not pick up a train quite so well as she would with the old valve.

r. Woodruff, Iowa Central Railroad—Mr. President, in this discussion

on valves I hear but little said about the travel of the valve. That, in my estimation, is a very important point—it is what virtually governs our power. On the engines that I have to contend with some have five and seven-sixteenth inches travel of the valve, and some four and five-eighth inches, and some have five inches. In one of the engines I have increased the travel of the valve from four and five-eighth inches to five inches, which has added greatly to the power of the engine. I would like to hear from the other members of the Convention relative to that point—the travel of the valve.

Mr. Hudson, Rogers Locomotive Works—I want to make a correction in regard to one statement of Mr. Jeffrey. He called the valve the "Rogers valve." It is true that the valves were made by Rogers, but they are what is termed the "Hackworth valve," there being a bridge in the center of the exhaust port and the valve having two bridges in it.

Mr. Jeffrey, Illinois Central Railroad—I apologize to Mr. Hudson for using the expression; we call them on the road "Rogers valves," and that is the reason of my using the term here.

Mr. Robinson, Great Western Railroad—Mr. President, before closing this discussion I wish to say that I think during the last half hour we have had ample proof of the necessity of a mechanical laboratory. There is no less than half a dozen gentlemen in this room who have been trying some experiment. Now, I ask, is it right that we shall always be obliged to pay for such experiments for the same engine on different railroads, or whether it would be better for all the railroads to pay one dollar instead of a hundred dollars in the end, to an institution that will try the experiments for them? If the mechanical laboratory controlled in the interest of any one line, or taking different lines every year, to conduct certain experiments to obtain certain ends, it seems to me that we would get the same results at about one-hundredth part of the cost. Instead of wasting money and everybody trying the same thing, we should have these results in this Convention year by year; and all those experiments which now we get in an abstract way, different ones trying the same thing with different views altogether, do not give the same results that would be given if it was gone about scientifically. This is only a side remark, Mr. President, to show that there is something in a mechanical laboratory.

Mr. Hudson, Rogers Locomotive Works—Mr. President, I merely wish to say a word with regard to the travel of the valve. When we talk about an outside and an inside lap we ought always to say how much travel the valve has, because if we alter the travel of the valve, the outside and inside lap being the same, the points or cut-off in the different notches and the times of the exhaust and operation will be varied, and therefore you will have different results from the same valve with a different lap, or you may obtain slightly similar results by altering the lead; for instance, in place of giving the

valve lead in the first notch, put it into the second notch, give it the amount of lead there, and you will obtain a result very similar to what you would by changing the valve and travel of the valve.

Mr. JACKMAN, Chicago, Alton & St. Louis Railroad—With regard to the travel I wish to say a word, Mr. President. We have no engine running with less than four and a half inches travel; we have some of them as little as four and a half inches, but we do not build anything with less than five inches, and the extreme travel of any that we have is five and one-fourth inches. I prefer either five or five and one-half inches. I do not know that I have seen any reason for increasing the travel beyond five and one-fourth inches for any useful purpose, so far as our engines are concerned. If we should put on some trains running fifty or sixty miles an hour, by and by with a track suitable for it, we might find it necessary to make a six inch travel, but five and a fourth inches is the travel on a large portion of our engines, and then there is another large portion which has five inches.

Mr. CHAPMAN, Cleveland & Pittsburg Railroad—As the time is rather limited, I would move that the discussion on this subject be closed.

Carried.

THE PRESIDENT—The next business in order will be to hear the report of your Committee on Locomotive Tires.

The Secretary read the Report.

Report of Committee on Locomotive Tires.

To the American Railway Master Mechanics' Association:

GENTLEMEN—Your Committee on "Steel Tires, Wheels and Axles, also Chilled Tires," have received replies from the Master Mechanics of sixteen roads, but the details in some of the reports were so few that we are unable to report upon more than eleven roads.

In the replies received some have stated the thickness of the tires when put on, and at the present time, but have omitted the mileage, others have estimated the mileage but not the wear of the tire, while a great many are of no value whatever.

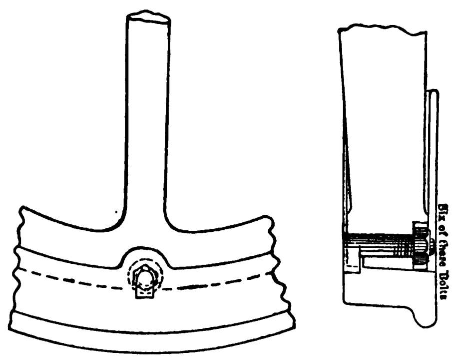
The superiority of steel tires having been already demonstrated, all that remains to be determined is which is the best tire, and how thin steel tires can be worn with safety. As it will take some time for the steel tires now in use to wear out, we are not likely to obtain the desired information in regard to either of those points for some time to come.

The whole number of sets which have been reported on is 359

Krupp	127	Nashua	11	Cammell	4
Frith	50	Bowling	5	Low Moor	4
Vicker	79	Naylor & Co.	3	Taylor	15
Butcher	43	Petin & Co	4	Bolton	2
Freedom	5	Washburne	5	Barrow	2

The performance of the above will be found in a table attach to this report.

METHOD OF PUTTING ON STEEL TIRES ADOPTED BY T ILLINOIS CENTRAL RAILROAD.



SETTING AND FASTENING STEEL TIRES.

Upon this subject we have received replies from fifteen roads.

Ten use shrinkage alone.

Two use shrinkage and set screws.

Three use set screws alone.

The amount of shrinkage allowed is the following:

Five allow $\frac{1}{100}$ inch shrinkage to 1 foot diameter of wheel.

One allows $\frac{1}{32}$ inch shrinkage to 5 feet wheel and less in pro tion.

One allows $\frac{1}{80}$ inch shrinkage to 1 foot diameter of wheel if tire is *soft*, and less shrinkage if it is *hard*.

One allows $\frac{1}{20}$ inch shrinkage to 5 feet wheel.

One allows $\frac{1}{16}$ inch shrinkage to 5 feet wheel; a $4\frac{1}{2}$ feet wheel secures by a screw as shown in tracing.

One allows $\frac{82}{10000}$ inch shrinkage to 5 feet and $5\frac{1}{2}$ feet wheel.

One uses set screws $1\frac{1}{4}$ inch in diameter, and allows shrinkage $\frac{1}{16}$ of an inch to $5\frac{1}{2}$ feet wheel, and the same proportion to a $4\frac{1}{2}$ feet wheel.

One uses set screws and allows $\frac{1}{32}$ of an inch shrinkage to $4\frac{1}{2}$ feet wheel.

One uses tap bolt through felloe of wheel, countersunk $\frac{3}{8}$ of an inch in the tire.

The Great Western of Canada uses set screws with thread of screw run $\frac{7}{8}$ of an inch into the tire, but has no thread cut on that part of the screw which passes through the rim of the wheel.

CHILLED TIRE.

The Illinois Central Railroad report having in use seventeen set of chilled tire in switching service on their road, of which no record has been kept.

The Southern Security Company, Lessees Memphis & Charleston Railroad, report seven set of chilled tire, of Mowry & Co's. manufacture, under engines, the average weight of which is 58,894 pounds, and the average mileage is 53,107 miles to the present time, and they are still in good running order.

The Jeffersonville, Madison & Indianapolis Railroad has one set of six tires; have been in service three years, which is about their average durability.

The Eastern Railroad, has one set Labdell's tire under a twenty-four ton engine, $4\frac{1}{2}$ feet driver, which has run to the present time 45,000 miles.

REMOVAL OF TIRE.

Have received reports from five roads only:

The Eastern Railroad (Massachusetts) removed one set of Vicker's *flange* tire after running 222,214 miles, and one set of Vicker's *plain* tire after running 190,759 miles; the thickness when put on or at the time of the removal is not given in the report.

The St. Louis, Vandalia & Terre Haute Railroad removed two sets, respectively $1\frac{5}{8}$ inches and $1\frac{11}{16}$ inches thick, on account of becoming loose; the maker's name and the mileage not reported.

The New York Central & Hudson River Railroad removed o set each of Vicker's and French tire $1\frac{1}{2}$ inches thick—did not co sider them safe any longer; no mileage returned.

The Atlantic & Great Western Railroad removed some when : inches in thickness for the reason they were becoming loose; tl number of tire, mileage, or maker's name not given.

The Jeffersonville, Madison & Indianapolis Railroad removed thre sets varying from 1 inch to $1\frac{8}{16}$ inches in thickness, on account c stretching and becoming loose; mileage or maker's name not given

STEEL DRIVING AXLES.

The Lackawanna & Bloomsburg Railroad reports thirty-two stee driving axles, about equally divided between "Krupp's" an "Nashua;" has had two break, one being a "Krupp" and havin run 170,780 miles, and the other "Jos. Parks" having run 127,54 miles; the fracture was probably caused by running off the track a switches.

The Eastern Railroad (Massachusetts) has in use ten of Krupp' manufacture and thirty of Vicker's; thinks their superiority ove iron justifies the difference in cost.

The Great Western Railroad of Canada prefers good axles (hammered iron.

STEEL TRUCK WHEELS.

But few roads reports upon this subject, but all who did spok favorably.

The Northern Railroad (New Hampshire) has in use about ninet steel tired trucks of Washburne manufacture which are doin splendid service, one set, for example, having run under a heav freight engine almost four years and are in good order at the presen time.

BREAKAGE OF TIRE.

NAME OF ROAD.	No. broken.	Name of maker.	Thickness when broken.	Miles run before breaking.	How secured.	REMARKS.
West Wisconsin	5	Am. Butcher.	$2\frac{1}{4}$	76,580	Shrinkage	
" "		"	$1\frac{7}{8}$	66,000	"	Cause unknown.
" "		"	$2\frac{1}{4}$	71,364	"	Slight damage in one case.
" "		"	$2\frac{1}{2}$	39,250	"	
" "		"	$2\frac{1}{4}$	40,086	"	
Eastern	2	Vicker		177,254	$\frac{1}{100}$ inch shrinkage	No particulars.
"		"		190,759	"	No particulars.
Detroit & Milwaukee	3	Butcher				No particulars.
Illinois Central	1	Vicker	$2\frac{5}{8}$			No particulars.
" "	1	"	$2\frac{1}{2}$			No particulars.
" "	4	"	$2\frac{1}{8}$			No particulars.
" "	3	"	2			No particulars.
" "	2	"	$1\frac{7}{8}$			No particulars.
" "	5	"	$1\frac{3}{4}$			No particulars.
" "	4	"	$1\frac{5}{8}$			No particulars.
" "	2	"	$1\frac{3}{8}$			No particulars.
" "	1	"	$1\frac{9}{16}$			No particulars.
" "	1	Eng. Butcher	$2\frac{3}{8}$			No particulars.
" "	1	"	$2\frac{1}{4}$			No particulars.
" "	1	"	2			No particulars.
" "	1	"	$1\frac{9}{16}$			No particulars.
" "	1	"	$1\frac{1}{2}$			No particulars.
" "	2	"	$1\frac{7}{16}$			No particulars.
" "	1	Freedom	2			No particulars.

General Average of Different Makers.

BRAND.	No. of set reported........	Average weight of engine	Average weight on each driver	Average mileage to 1-16 inch wear..................	Highest run of single set to 1-16 inch wear...	
Krupp	119	58,183	9,049	10,561	31,467	
Firth........................	50	58,154	10,131	14,015	37,267	
Vicker	78	58,211	9,250	15,059	71,558	
Butcher, English.........	24	62,708	10,479	19,778	55,066	
Butcher, American......	19	58,517	9,776	16,214	51,218	
Freedom......................	5	45,900	5,750	6,640	14,854	
Nashua	11	60,900	....	21,231	51,087	1
Bowling.........................	5	60,500	9,800	6,706	13,512	
Naylor & Co................	3	....	8,428	9,966	11,581	
Petin & Co..................	4	....	....	22,178	34,380	
Washburne.................	5	....	....	9,622	15,035	
Cammell......................	4	60,715	10,171	19,307	31,528	1
Low Moor..................	4	52,286	8,346	12,655	18,508	
Taylor	12	....	8,800	18,131	47,611	1
Bolton........................	2	63,000	....	9,712	9,834	
Barrow.	2	60,000	....	11,416	13,851	

Respectfully submitted,

J. N. LAUDER, *Northern R. R.*,
ALBERT GRIGGS, *W. & N. R. R.*, } *Com*
F. A. WAITE, *B. & M. R. R.*,

On motion, the report was received.

The President—I take occasion here to call the attention of the bers to their duty in answering the circulars sent out by the comı You see, by this report and several others, that out of some two hundr sixty or seventy members, we have but very few answers. Each meml answer the circulars or some parts of them. I make this remark in of the committees and their reports; it is a duty we owe to this Asso to answer, in every instance, the circulars that our committees send out subject of the report of your Committee is now open for discussion.

Mr. Wells, Jeffersonville, Madison, & Indianapolis Railroad—Mı ident, I see by the report of that Committee that the road I represent

…PORT ON TIRES.

	Highest run of single set to 1-16 inch wear	Lowest run of single set to 1-16 inch wear	No. of set reported on	Average weight of engine	Average weight on each driver	
Butcher…						
Mem…						
East…	,558	8,070	Am. 5	48,100		2…
Terr…	,925	10,725	Am. 12	61,451	9,776	1…
Old (…	,291	5,487	1			2…
Flin…			5			1…
Lack…			3	66,500	9,838	1…
Jeffe…						
Illin…	,859	5,665	Am. 2 Eng. 8	66,000 59,750		1… 1…
Wes…			4	61,250	9,934	
East…			3	63,333	11,666	1…
Nor…						
Petin &…						
Men…						
East…			1	41,640		
Old…			1			
Flin…			2			
Lack…						
Jeffe…						
Illin…						
Bolto…						
Mer…						
Eas…	…511	11,310				
Ter…						
Old…						
Flit…	…179	10,229				
Illi…			2	63,000		
Nor…	…500	5,567				

tate the number of miles made by the set of tire worn out. It is my impression that I gave the mileage, although I may be mistaken about it; but, anticipating that this subject would come up for discussion, I had a few minutes' leisure before I started, and I went to the books and took off a memorandum of the mileage of two or three sets of steel tires that were worn out; and in regard to this subject I will state that one of the locomotives under which a set of steel tires was worn out, previously had a set of iron tires of the same thickness, and it was worn down to the same thickness that the steel tire was when it was thrown away. The mileage made by that set of iron tire was 76,620, which was equal to 3,821 miles as made to the one-sixteenth of an inch. That one-sixteenth of an inch included the amount taken off during the different turnings. A set of steel tire under the same locomotive, engaged in the same service—hauling freight—run 7,652 miles to the one-sixteenth of an inch, just about double the mileage of the other. The steel tire was Vicker's manufacture. The total mileage of that tire was 15,346 miles. I will state that the tire was only two and three-eighth inches thick when it was finished on the wheel. Another locomotive, No. 12, with a five-foot wheel, made a mileage of 151,476 miles until the tire was worn down to one and an eighth inch in thickness. That was an average of 7,573 miles to the one-sixteenth of an inch, and included, of course, all the various turnings. Another locomotive of the same size, a five-foot wheel, made 181,059 miles, which was equal to 9,052 miles to the one-sixteenth of an inch. Another one made 152,334 miles, until the tire was worn out, an average of 7,616 miles to the one-sixteenth of an inch. The weight on the first engine upon each driving-wheel was 8,950 pounds; upon the second one was 9,640 pounds; the third one was 9,075 pounds; and the fourth one was 9,400 pounds. These four sets of tire averaged nearly the same. There were four sets in all; one of them was Vicker's tire, and the other three were Krupp's.

Mr. JACKMAN, Chicago, Alton, & St. Louis Railroad—Mr. President, I am very much pleased with the remarks of Mr. Wells, so far as the operation of his steel tire is concerned, and as far as our practice goes, taking the wear of the tire that he has given us here, it corresponds almost exactly with my experience. For instance, if I take a tire of iron and wear it out, and then a first-class steel tire and wear it out, I find that the steel tire gives just about twice the service that the iron tire does, and that we wear out steel tire on our freight engines in about five years, and the iron tire we wear out in about two and one-half years. Our tires do not run 15,000 miles to the one-sixteenth of an inch, wearing either in freight or passenger service. We have, in one or two instances, put on light engines the "Butcher tire" that were made when they first commenced making tire, and they were hard like glass or flint. Those worked extraordinarily well; but then that is no measure for the general wear of iron tires; and I want to say that so far as the cost of steel tires is concerned, we could not afford to use iron tires if they were given

to us, taking steel tire at the price we pay for them. I would not undertake to do it, because, in the first place, the steel tire after once set does not get loose until it gets down pretty thin. I make a practice, however, not to run our steel tire down to less than an inch and a half. That is about as low as I dare run a steel tire unless it be on some engine that is working in the yard, or where it does not get out on the line. When they get as thin as that I consider it is better to take them off than to run with them, risking their breaking when there is some frost in the ground, or when the track is frozen pretty hard, because it puts us to more trouble than it would to remove the tire earlier.

Mr. BROWN, Western Division of the Delaware, Lackawanna, & Western Railroad—I would like to inquire what thickness of tire wears out in five years' time.

Mr. JACKMAN, Chicago, Alton, & St. Louis Railroad—Two and a half inches, or two and three-fourth inches. I do not order any now less than two and three-fourth inches; but still the first we had were two and a half inches. After they were put on they turned up full two and a half inches.

Mr. BROWN, Western Division of the Delaware, Lackawanna, & Western Railroad—That really would not be a great mileage. Forty thousand miles is generally a large mileage per year for a locomotive, and if it was worn out in five years' time, that would only be 200,000 miles. We have instances of tires wearing 150,000 miles without turning.

Mr. JACKMAN, Chicago, Alton, & St. Louis Railroad—They don't do that for us though. I want freely to express that, and to be fully understood. I know that people tell me about tires running 100,000 miles. One man says to me here a year or two ago: "All our tires are running on the second hundred thousand miles and have never been taken off yet." I looked at him with astonishment, and asked what his engines did: "Do they do anything?" Ours don't run anything like that. After they have run 20,000 or 25,000 miles they want turning. That is the experience I have had. I don't know whether our engines do harder service, or whether our track is more slippery, and they have to use more sand going over the same ground; but I know they wear these tires out in less time than some people talk about.

Mr. SEDGLEY, Lake Shore & Michigan Southern Railroad—I would like to inquire of Mr. Jackman what cause leads him to remove a steel tire at an inch and a half thickness? Upon our road it is not an infrequent thing for tires to be an inch thick, and not become loose upon the wheel, and we have had no trouble in running them; besides, I think that the mileage is worth a great deal more to us after the tire is an inch and a half thick than when it is two and one-half inches thick. I simply ask for information.

Mr. JACKMAN, Chicago, Alton, & St. Louis Railroad—Mr. President, I will state the reason which Mr. Sedgley asks for. Here, two winters ago, we

had a pretty hard winter. I sent two engines out with tires a little more than an inch and a half thick in each case; they got out about twenty miles, and I had to send out and pull both engines in with a broken tire, while our engines with tires thicker than that stood it all through; but I found when they got down to that they would not stand hard winter service. Therefore I concluded that it was not best to risk the lives of the people connected with the train.

Mr. SEDGLEY, Lake Shore & Michigan Southern Railroad—Whose make of tire were these you speak of?

Mr. JACKMAN, Chicago, Alton, & St. Louis Railroad—Those were the Vicker tire that I speak of.

Mr. HAYES, Illinois Central Railroad—I was going to ask the same question—the thickness of the tire when they were taken off, and whose make they were. We have worn out on our road quite a number of sets of tire, and especially in the summer time, and we have not taken them off until they got down to, say an inch and a quarter, or an inch and three-eighths in thickness. We have run through the cold win ters also in a great many cases with them down even as low as that—through the severe winter that we had two years ago. I think that tires may be run with safety in the summer time much thinner than Mr. Jackman speaks of.

Mr. JACKMAN, Chicago, Alton, & St. Louis Railroad—In the summer time I have no doubt but that it would be safe.

Mr. HAYES, Illinois Central Railroad—The average life of a tire in my experience has been about five years, about the same as Mr. Jackman's experience, and the average thickness is about two and three-quarter inches. The number of miles averaged by tires, as shown by the report of the Committee, according to my recollection, is 165,000, taking passenger and freight together. However, I would state that the early tires that were put on were only two and a half inches thick, while those that we use now are two and three-quarter inches thick. I think that the general average, so far as the wear is concerned, and the turning, would be about 10,000 miles to the sixteenth of an inch; but, taking, as I heard Mr. Wells say, the whole thickness of the tire—

Mr. WELLS, Jeffersonville, Madison, & Indianapolis Railroad—No, sir; I took the thickness of the tire from the time that they were put on new until they were taken off.

Mr. HAYES, Illinois Central Railroad—Then our experience will run above yours. Ours will run about 10,000 miles while yours is about 7,000.

Mr. MILES, of Philadelphia—Mr. President, I would like to ask Mr. Wells, who has given us such careful figures on those four sets of tire, whether he can fix upon any definite amount of wear to turning—that is, how much they will wear before you have to turn them—whether it is constant, or whether it varies?

Mr. WELLS, Jeffersonville, Madison, & Indianapolis Railroad—I presume that there is nothing definite about it. It depends almost entirely upon the service rendered by the locomotive. I find that locomotives pulling freight trains on level roads will not make as great mileage per one-sixteenth of an inch wear as those running on grades where the grades are up and down, from the fact that those running upon level roads are loaded down to about their capacity to draw, and it is a constant pull the entire length of the road, and there is an imperceptible slip—as you may call it—going on constantly under the tire, while the locomotive is running; in other words, the revolutions of the tire are greater in number than is due to the length of the track passed over. Although the slip may not be perceptible to the eye, it is taking place constantly; and it is that imperceptible slipping that is going on all the time that wears the tire of the locomotive so fast on a level road drawing freight trains. I also find that our locomotives running on passenger trains will make very much larger mileage to the one-sixteenth of an inch wear than those hauling freight. Our road is comparatively level, and the freight locomotives are loaded down to about all they can pull and draw to their full capacity nearly the entire length of the road. We have one passenger locomotive that has made 135,425 miles, and the tires are not yet worn out; and so far as they have worn the average mileage to the one-sixteenth of an inch wear has been 13,542 miles. The weight upon those tires is 10,050 pounds. Now, there are two freight engines with a little smaller wheel with 10,025 pounds weight upon each wheel that have made only 8,822 miles to the one-sixteenth of an inch wear, and 9,182 miles to the one-sixteenth of an inch. These are freight engines with the same weight upon the driving-wheels as the passenger engines, and make 9,183 miles against 13,542 miles run. I find that the freight vary from the passenger locomotives just about in that proportion. We have other passenger engines, one of which has run as high as 31,205 miles to the one-sixteenth of an inch wear; another one has made 29,600 miles.

Mr. FARIES, Atchison, Topeka, & Santa Fe Railroad—What is the difference in diameter?

Mr. WELLS, Jeffersonville, Madison, & Indianapolis Railroad—There is in some of these one foot of difference in diameter. The locomotive that made 31,205 miles to the one-sixteenth of an inch wear has 10,625 pounds upon each wheel—heavier than the freight engine—and five and a half-foot wheel. The one that made 31,205 miles to the one-sixteenth of an inch wear was Butcher's tire, of Philadelphia. It goes under another name now, but it was made at the Philadelphia Butcher Works. And the one that made 29,643 miles was Vicker's tire; and the one that made 13,542 miles was Moulkbarry's tire.

Mr. LAUDER, Northern Railroad, New Hampshire—I see from the lists of subjects for committees to report upon for the ensuing year the subject

of Wheels and Tires, and I would like to refer to the importance of members giving us a little more material upon which to make a report. I am now assuming that I shall be on that committee, which may not prove to be the fact; but no matter whether I am on it or not, unless the committee can have a little more material it will be almost useless to make a report on the subject. I would also urge upon members the importance of giving us facts that are available, and not a general idea of what they are doing. I have noticed that the men who give us the best reports of steel tires, the most elaborate, go into the most details, invariably show that their engines make the poorest mileage to the one-sixteenth of an inch wear. My idea is that we don't get as much mileage to the one-sixteenth of an inch wear as these reports show. I find that those that go into details—and I have no doubt that their reports are accurate—never show the amount of mileage to the one-sixteenth of an inch wear that those we report give us as a general average. Last year I had a letter from an important road in this country, giving no details whatever, but simply saying they had so many sets of steel tires, and that their average mileage to one-sixteenth of an inch wear was thirty thousand miles. I don't think that that can be so. Certainly it is contrary to all my experience, because I can not get sixteen thousand miles; I would therefore urge upon every man, if he answers these circulars, to give us facts.

Mr. Stratton, Pennsylvania Railroad—Mr. President, I would like to ask in measuring tires, whether the gentleman when the tire is worn out measures the turning and all, or whether only that portion of the tire which is worn away by friction? I should think that to measure only the amount that is worn would be the proper way. That made me think that calculation was a little low for steel tires.

Mr. Jackman, Chicago, Alton & St. Louis Railroad—Mr. President, I would state my method of doing that. I put a set of tires on wheels for an engine and send them out. They are turned truly and carefully when they go out. After they have run a certain time and are taken in for turning, I find the lowest spot in the smallest tire of the lot, have it put into the lathe and I direct my man who turns them to always leave the spot of the original wear on that tire so that he can show me, if I complain, that he turns the tire too much, that he has not done it, that there is some of the original part of the wear left yet. I require that in all cases. That is the measure of what I consider the wear of the tire up to the time it has been run. I measure into the lowest spot, because you have got to turn them to that at any rate. In regard to what our friend Lauder has said, it is never too late to repent they say. I have been exceedingly negligent in years past in giving these returns and making replies to these questions that are asked, I will endeavor, if God should spare my life and health for a year to come, that I will be more faithful in that particular. I have sometimes been ashamed to send in any report, saying that we run tires and only get six or

seven thousand miles to one-sixteenth of an inch wear, when the Master Mechanics' Convention reports that the average wear is fifteen thousand miles to one-sixteenth of an inch wear. It looks as though I were not doing my duty, and as though I did not get the service out of these tires that other people do. Whether they get that amount or not I do not know, but it seems to me a very astonishing fact.

Mr. LAUDER, Northern Railroad, New Hampshire—I don't know whether I quite understand Mr. Jackman, as to whether he measures the tire after it is turned or before it is turned. I want to know whether he measures the tire before it is turned, and takes the difference between the two for the wear?

Mr. JACKMAN, Chicago, Alton & St. Louis Railroad—I measure the tire in the beginning before turning at all. Then after turning I measure it again. For instance: If I put a set of tires on that measure sixty inches when they first go out on the road, and then, after they have been run and have been turned off they measure a quarter of an inch less than sixty inches, why I conclude there has quarter of an inch been worn off from the tires from running.

Mr. LAUDER, Northern Railroad, New Hampshire—I understand it now. That is precisely my system. I measure the tire after it is turned; and the date and size of the tire at that time is recorded. When the engine comes in again for tires it is measured. In that way you get the actual amount of wear for the actual amount of mileage, although part of it is turned off. Now, it seems to me, that those men that made reports of engines running and making such enormous mileage may have been calculating in another way, estimating what the thing had worn, not taking into account what had been turned. I certainly could come to no other conclusion, because every man I think in this Convention that knows any thing about the wear of steel tires will say it is impossible for heavy engines in heavy service to average thirty thousand miles to one-sixteenth of an inch wear.

Mr. WOODRUFF, Iowa Central Railroad—I would like to ask Mr. Jackman, Mr. Hudson, and Mr. Wells what their usual practice is in setting tires about shrinkage? or whether they use water or let the tire cool in the open air?

Mr. JACKMAN, Chicago, Alton & St. Louis Railroad, Mr. President—I will explain our method. I take a tire that has to be put on wheels, say, for instance, the wheel center is sixty-two inches in diameter, I give to that tire one-sixteenth of an inch shrinkage. If the tire will not bear one-sixteenth of an inch shrinkage I do not care to have the tire on, and the sooner it breaks the better. We heat those tires to what we call a black heat. If you take a pair of gloves or mittens you can hold them. We heat them so that they will just barely slip on to the wheel. Then we let them stand in the yard and I allow a man to take a sponge, or rag which is better, and sop

it in a bucket of water and put it on to the rim of the wheel, not the tire. I do that to keep the rim of the wheel cool; that is continued till the tire gets cool enough. That is the method that we use. For a wheel that is fifty-six inches in diameter I give about one-twentieth to one-sixteenth of an inch shrinkage to the tire.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—I will state, Mr. President, that my practice has been in fitting tires to the wheels to allow from one-eighteenth to one-sixteenth of an inch shrinkage for a five foot wheel. If a wheel center is a new one, never has had a tire on before, I make a little difference for that, because that would compress a little more than the old wheel center. If it is soft iron from one-eighteenth to one-twentieth of an inch is what we allow for a five foot wheel. In regard to cooling tires I have always been in the habit of using water, and have never experienced any difficulty. I have never had any tire break of all that I have ever used. In regard to the wear of a tire to a one-sixteenth of an inch, if that matter is investigated closely it will be found that tires on trains run on a level road, where the engines are loaded to their full capacity, will not make as many miles to a one-sixteenth of an inch wear as upon roads where there are grades. For instance, take a road one hundred miles long with the grade ascending one-half the way, and descending the other half of the way, now a locomotive can only be loaded to the capacity to load the train up the grade and no more, and when going down, when but little power is being used, there is none of this slipping that is going on constantly when the locomotive is pulling hard. During the fifty miles of up grade she is not wearing her tire any more than she would be running fifty miles on a level road, and going down the other fifty miles her tire is not being worn except simply by the weight of the wheel resting upon it as it turns over when it comes into contact with the rail. What would be the fair mileage for one-sixteenth of an inch wear on one road would, perhaps, not be regarded as equal on another road, on account of the difference in the circumstances.

Mr. MILES, of Philadelphia—I have no doubt, Mr. President, but one great difference—and an important one—in the experience of the wear of tires on different roads is the condition of the track, with which the Master Mechanic has nothing to do except to complain about it. That may account for a considerable difference, and the grade of the roads cause another difference. I wish to ask a question of these gentlemen: Starting with a tire we will suppose three and a half inches thick, and running it down to an inch and a half thick, which makes a difference of two inches in the diameter—and some of them run it down to one and a half inches thick, making a still greater difference in the diameter of the wheel—it makes a great many more revolutions than it did where it was two and a half inches thick. Now I wish to ask whether the gentlemen have noticed that the wheel gave

more mileage as it ought to do to a one-sixteenth of an inch wear when it was new than it did when it was worn down thin? I understood a remark Mr. Sedgley, of the Lake Shore & Michigan Southern Railroad made, that the mileage was worth more to them when the wheel was made small, when it actually made more revolutions to the mile, and of course must wear more, than it was worth when it was of a greater diameter.

Mr. SEDGLEY, Lake Shore & Michigan Southern Railroad—I wish to state to Mr. Miles, in reference to the mileage being worth more, we had less dead weight to carry. I didn't mean you to infer that we got a larger mileage per one-sixteenth of an inch; but we all know that the weight we have below the springs is very much more injurious to the track than that which is above the springs, so that I always considered that the thin tire, so long as it is tight and answers the purpose, is much more valuable than a thick tire to the company.

Mr. MILES, of Philadelphia—I am much obliged to Mr. Sedgley for his information, and now that he has explained it, I wish to ask whether the advantage of the thin tire is such as to counterbalance the advantage of the thick tire with regard to diameter, so that no difference is perceived in the mileage?

Mr. JACKMAN, Chicago, Alton, & St. Louis Railroad—I think, so far as that is concerned, there is so little difference—taking it as a whole—that it would be hardly perceptible. I just figured the revolutions in a wheel between here and St. Louis with wheels sixty inches diameter, and fifty-nine inches, and the difference is much less than one would think. Now, with regard to the grade of the road. Between here and Joliet our road is what you might call comparatively level. From here to Joliet our engines take from twenty-eight to thirty cars. Then they have the Joliet grade to get up; and after they get up there they put on all the cars that they can find along the line for over ten miles of road. Then there is another part of the road where they let off part of them. Further on again they will take on more. And so our road is scheduled all over as to how many cars they shall pull between such and such places, and our engines are generally loaded down to that extent.

Mr. WELLS, Jeffersonville, Madison, & Indianapolis Railroad—I will state in answer to Mr. Miles, in reference to making this calculation of mileage, if a tire is, for instance, two and one-half inches thick when it is put on new, and when it is taken off it is an inch and a quarter thick, then there is twenty-sixteenths of an inch in thickness gone. Now, part of that has been worn away and part turned away, and if the locomotive has made a mileage of 200,000 miles when the tire is removed, then it is evident that she has made 10,000 miles to a one-sixteenth of an inch wear. That is the way in which I have counted it. It includes the part of the tire that is worn away and turned away.

Mr. JACKMAN, Chicago, Alton, & St. Louis Railroad—You take the lowest spot, of course?

Mr. WELLS, Jeffersonville, Madison, & Indianapolis Railroad—Yes.

Mr. JACKMAN, Chicago, Alton, & St. Louis Railroad—That is the way we do it.

Mr. MILES, of Philadelphia—The diameter of a new wheel is sixty inches, I believe; and the difference between the extreme thickness of the tire and the extreme thinness of it is a little over four inches, which is one-third of a foot, so that the difference in the number of turns that the circumference of the wheel would pass over the track would be one-fifteenth of an inch, and when you get the four inches off, your wheel turns one-fifteenth of an inch more than it did when you had the whole five feet. So that in running from here to St. Louis you would have one-fifteenth of an inch of it in favor of the tire—you would not have quite that, because you would be on a constantly-decreasing scale. But in a mileage of a tire one-sixteenth of an inch would certainly not be an insignificant amount.

Mr. GRANT—I have taken considerable interest in this discussion. I do not think we have arrived exactly to the true point. There is a certain amount of wear, and a certain amount of turning off, and also the amount that is thrown away, that is not taken into consideration, I believe—I don't know. I think that part that is thrown away ought to be taken into consideration.

Mr. LAUDER, Northern Railroad, New Hampshire—It must be particularly understood that the amount of the tire that is lost in running a certain number of miles is the wear, as it seems to me, whether it is worn off or turned off. It is gone, and should be considered as wear. We can not very well reckon the thickness of the tire that is left on when it is worn down. All that we make any reckoning for, is for comparison from which to make statistics. If tires were universally alike, there would be no cause for investigation. I would say, in answer to Mr. Miles, that I suppose it is well understood that the first wear of a tire is the best. One reason is that the tire is a little larger, and doesn't have to make so many revolutions; the other is that the metal is harder and of better quality near the surface than it is toward the center.

Mr. HAYES, Illinois Central Railroad—Mr. Lauder, in speaking, just reminds me of our mode of specification in ordering tires. I find that Mr. Wells and Mr. Jackman both give a less wear to the one-sixteenth of an inch than is the average upon our road. I would state that in ordering tires we specify the outside of the tire that must be rolled perfectly to a gauge and uniform in size, so that we don't do anything to the outside of the tire. We simply bore it out to the proper size, then shrink it upon the wheel. Hence I think that we get a much better wear by not turning the tire on the first wear than most roads. I believe that if that mode is followed that the re-

sults in the wear to the one-sixteenth of an inch would be much greater than that spoken of by Mr. Jackman or Mr. Wells.

Mr. JACKMAN, Chicago, Alton, & St. Louis Railroad—If we find the tire on the outside true enough we do not turn them. But I can not get tires so that I can bore them, and then put them on wheels and have them perfectly true on the outside; so we turn them.

Mr. WELLS, Jeffersonville, Madison, & Indianapolis Railroad—I would state that the tires we put on new we sometimes find no occasion for turning them. The set-off tires that I reported here as having been worn out were among the first steel tires that were made; and the diameter of them were different. They were not made so carefully as they are now; and, therefore, we were obliged to turn off those spots.

Mr. FARIES, Atchison, Topeka, & Santa Fe Railroad—I wish to inquire if there is any difference in the wearing of tires taken into account where the engine is backing probably one-half the time, switching, etc., where the tire has to be turned off for the special benefit of the flange and not the face of the tire.

Mr. WELLS, Jeffersonville, Madison, & Indianapolis Railroad—As far as I am concerned I never had occasion to turn off a tire on that account.

Mr. FARIES, Atchison, Topeka, & Santa Fe Railroad—Take, for instance, a road that will stretch out from 100 to 150 miles before there is a turn-table provided, the consequence is that they have to back as many miles as head; and the engines, built frequently in a hurry, are very often not as square on their drivers as they should be, and there will be more or less oscillation on one side or the other of the leading wheels, and the consequence is the flanges are often worn, but the face of the tire is not. That pair of drivers must be turned at the expense of the flanges, consequently all four must be reduced alike. Now, I wish to know whether in making these returns a specialty should be made for that class of wear?

Mr. LAUDER, Northern Railroad, New Hampshire—It seems to me that makes very little difference with regard to the wearing of the tire. My idea is, and my experince has been, that the oftener steel tires are turned—provided you just skim them—the more mileage you are enabled to get out of those tires. It is well known when the tire begins to get a little flat, or gets running upon a flange, it wears very rapidly, and if one tire is smaller than the rest it seems to grow smaller than the others; whereas, if that tire is taken in, and they are all turned alike, they run some time before that soft place gets worn down too far again. So I think you can get more mileage out of them by turning them off than by allowing them to wear excessively before turning.

On motion, the discussion was here closed.

THE PRESIDENT—The next subject in order is the report of the Committee on Standard Axles. The Secretary will read the report.

Report of Committee on Standard Axles.

To the American Railway Master Mechanics' Association:

GENTLEMEN—The Committee to whom this subject was referred at the last Convention of this Association, after careful investigation, recommend the adoption of the following dimensions as a standard for the form and proportions for freight and passenger car and tender axles: Total length over all, 6 feet $11\frac{1}{4}$ inches; journal, $3\frac{3}{4}$ inches diameter by 7 inches long; wheel-seat, $4\frac{7}{8}$ inches diameter by 8 inches long; diameter in center, 4 inches; collar, $4\frac{3}{4}$ inches diameter by $\frac{5}{8}$ of an inch thick. The Committee are of the opinion, owing to the great diversity in the construction of locomotive engines, that no standard for the form and proportions could be adopted in the construction of the axles without first making important modifications in the design and dimensions of other parts of locomotives. Such modifications the Committee do not believe were included in the subject they were appointed to consider. They, therefore, recommend that this Committee be discharged from further consideration of this subject.

Respectfully,

M. N. FORNEY, *Railroad Gazette*,
COLEMAN SELLERS, *Philadelphia*,
GORDON H. NOTT, *Boston*,
Committee.

On motion, the report was received.

Mr. WELLS, Jeffersonville, Madison, & Indianapolis Railroad—The Committee have specified a certain diameter of axle, and a certain diameter of journal; but we may, some of us, differ in opinion in regard to whether that would be the best standard to adopt, and we would like to have some reasons given by the Committee. Perhaps they can satisfy us that that is just the size it should be.

Mr. FORNEY, Railroad Gazette—It will be remembered that there was a vote authorizing this committee to confer with a similar committee appointed by the Car Builders' Association. As Chairman of that Committee I was present at the Convention in Boston, and heard the discussion and took part in it. On a very thorough discussion and examination of the whole subject that Association fixed upon the standard which has been named in our report. I presumed that all the members were famílliar with the reasons stated, but it is extremely difficult to give any exact reasons for any special

size. Whether the journal should be three and one-sixth inches, or whether three and five-eighths, three and seven-eighths, or three and one-half inches, is simply a question of opinion in a great many cases—it is impossible to give any exact reason for it. Of course, if a standard axle is to be fixed by this Association, and the Car Builders have adopted one, if this Association adopts the same, it will be much more likely to come into use than if we differed; but if there is any good reason why the Association should differ from the Car Builders, of course, it remains with the members here present to say so.

Mr. FELLOWS, Lake Shore & Tuscarawas Valley Railroad—I have had some experience with the large journal as adopted or recommended by the Car Builders' Association, and am very glad that this subject has come up, and it will be well if the opinion of the representatives to this Association be obtained and a general discussion entered upon by the members. We were using on the Lake Shore & Tuscarawas Valley Railroad previous to that recommendation a journal three and one-fourth by five and one-half inches; after that recommendation we had a hundred cars built with the large journals three and one-fourth by seven inches (the tracings of the box and the journal are all in the March number of the Car Builders' Journal), and those cars were put on our road in August last. The experience we have had is decidedly in favor of this standard as compared with the smaller journal. The first glance at it, without the demonstration gained only by experience, would convey the idea that the larger journal would cause more friction and be more expensive to handle; but the argument in favor of the large journal is that the better lubrication would overcome that, and certainly our experience in brasses and oil with these large journal cars tends strongly to confirm that argument. We have had less trouble with hot boxes with these large journals than we have had with the other size that we were using before.

Mr. JEFFREYS, Illinois Central Railroad—I would suggest that it is a matter of great advantage to any road to have a uniform standard of axle and boxes for cars so that they may be interchangeable; and the advantages of this are so apparent that when the Master Car Builders of the country adopt a standard axle for cars, and that comes into general use, it points strongly toward the fact that the Master Mechanic adopt the same. If one road adopts a certain standard axle for its cars, and that road finds it to its own advantage to have the same axle to its tenders, it seems to me other roads would do the same thing. I think by adopting a standard tender axle, or a standard car axle, the uniformity should be broad enough so that all axles would be alike interchangeable for tenders and cars. I have known cases along the road where an accident has occurred in the way of breaking tender axles, and a flat car, a coal car, or some other car, lying along the road has been jacked up and a pair of wheels put on, and it has gone along;

and it will often happen that this can be done, provided this uniformity is had.

Mr. FORNEY, Railroad Gazette—Since the adoption of the standard axle by the Car Builders' Association, I have had opportunities of getting the opinion of a number of gentlemen who have adopted that standard axle, and uniformly those gentlemen spoke in very high terms of it, so far as regards economy and the resistance of the cars. Some experiments were made on the Boston & Albany Railroad, an account of which I regret I have not with me, in which it was shown that the resistance of a car with a big axle was less than with the smaller axle. I have also met several gentlemen who were opposed to its adoption, thinking it was too much weight, that the journals were larger than necessary, and I believe in every case the gentlemen who have experimented with it have been convinced of the advantages of the large axle. Mr. Gary, of the Harlem Railroad, made some experiments which have been reported, in which he took brasses for three different-sized journals, and rode them under the same car for the same length of time, and in each case the smaller journal lost most in weight; in the second-sized journal the brass lost a little less weight, and in the largest journal the brass had lost the least, showing that the wear of the brass on the large journal was less than it was on the smaller-sized journal. The experiments seemed to be very satisfactory, and I have every reason to believe it was conducted with the utmost fairness, and with the intention of arriving at the truth in regard to the subject. On the Reading road they have, for a great many years, used a journal which, my impression is, is four by eight inches. Mr. Merrill, do you remember the size?

Mr. MERRILL, I don't remember now, positively.

Mr. FORNEY, Railroad Gazette—My impression is four by eight inches; and I do not think that they could be induced to go back to a smaller-sized journal, although it is that much larger than the standard adopted. I feel certain, in my own mind, that any member who has any doubts about the question, would be very soon convinced, if he put it into practical use. Probably Mr. Stratton can tell the length of the Pennsylvania axle. It is an inch longer than that.

Mr. STRATTON, Pennsylvania Railroad—The Pennsylvania road is seven inches long, but three and one-half inches instead of three and one-quarter inches.

Mr. WELLS, Jeffersonville, Madison, & Indianapolis Railroad—I believe that the journals that the Reading Company use are eight inches long. They have a recess turned in the middle of the journal, perhaps two inches in length; that is three-eighths or half an inch smaller in diameter than the other is at such a point; and the whole bearing is eight inches in length, counting its recess in the center. Now, I am perfectly satisfied about what Mr. Forney says in reference to the wear of these journals, and no objection

at all can be urged against that size, in my judgment, except the weight. The only question is, whether there is not more weight carried in a freight-car axle of that dimensions than is absolutely necessary to do the proper amount of work. An eighth of an inch in diameter makes a considerable difference in the weight of an axle, when you come up to a diameter as high as four and one-half or four and three-quarter inches. I have never investigated the matter closely enough to ascertain whether a smaller size—perhaps an eighth of an inch smaller—would not do just as well as that size that is adopted, and thus save dead weight and first cost.

Mr. EDDY, Boston & Albany Railroad—Our road have built some cars with this axle, and have made such alterations as have been necessary in getting it into use. The axle weighs a little short of 100 pounds more than the axle we have been using; with all the appurtenances the brasses weigh three and one-half pounds more, I think, each; then there are the housings, and such like, so that each car will weigh about two-thirds of a ton more with that axle and its appurtenances than with the old kind. Now, there is the first cost of this. Then they undertake to tell us that the cars run easier. Mr. Forney mentions some experiments that have been tried on the Boston & Albany road, but I very much doubt whether there have been any experiments tried there that are in any way satisfactory. We all know that on a level road perhaps you would not feel that quite as much, but take a road with grades like ours for twelve successive miles, and if you get weight to take over that line you have got to have something to do it with. I made a little estimate of it, and satisfied myself that the Boston & Albany Railroad would have to haul at least 200,000 tons more over their road in the course of a year with that axle than they would with the other kind. This question of a big axle is, in my estimation, a thing not to be passed over lightly; and before this Convention takes any action on it I propose that we shall look at the thing pretty closely.

Mr. LILLY, of Indianapolis—In conversation with the members of this Association, in years gone by, Mr. Towne (?) made use of the expression that there was a very great deal due for decrease of friction by the large axle in the decrease of deflection. The Reading Railway introduced a long journal—very much longer than the standard that has been adopted by the Master Car Builders—an inch or an inch and a quarter longer, I think, but a little smaller in diameter; the diameter of wheel-seat is, however, about the same. Now, I think it is a pretty well-settled fact, that as is the amount of pressure upon a given number of inches upon a rolling surface, such will be the friction as per number of inches, and the amount of pressure on that, and the speed at which it runs; but I think a very great deal is due, as I said in the start, to the decrease of friction by the decrease of deflection of that axle. Now, that axle springs under a freight car, under a heavy load, with the load suspended over the end of the axle, very much more than the

majority of people have any idea of—as much as half an inch or three-quarters of an inch—that axle is constantly rising up in the middle where the axle has been turned down very small in the center. And I think that the increased friction for a small journal, or small axle, is perhaps quite as much due to that fact as it is to the increased size in the other case. As Mr. Eddy says, with the increased weight, you have an extra expense for carrying this material—this increased load. I think that Master Mechanics are staggering under the excessive size of axles that car builders are using—these luxurious passenger cars—for instance, weighing thirty to thirty-five tons; twelve to fourteen tons is what a passenger car used to weigh. Roads of heavy grades feel that very much more than level roads do, of course. In the discussion of this matter, which is as has been said here, of great importance, there are a great many circumstances which enter into it that are not to be lost sight of.

Mr. Peddle, St. Louis, Vandalia, & Terre Haute Railroad—I certainly think we ought, if possible, to adopt some axle that all will be satisfied with. Statements have been made in circulars, which have been distributed all through the country to Superintendents, to the effect that increasing the diameter decreases the friction. Now, that I can not understand. I am very sorry that I was not in when the report was read, but if Mr. Forney will explain this difficulty he will do much to clear up this whole matter.

Mr. Forney, Railroad Gazette—I will be glad to say all I know about it. I think, however, Mr. Sellers will probably make this much more clear than I can. I will only say this, that as far as I understand the subject, there are two important elements. One is what has been called the co-efficient friction, and the other is the question of lubrication. If you have a small journal you have a tendency to press out the oil; if you increase it the pressure allows the oil to remain in, and it is much more perfectly lubricated, and, therefore, the motion is easier than it would otherwise be. It is quite true you lose something on account of the larger diameter; but what you gain from the perfect lubrication is much greater than what you lose from the other cause. Of course it would be possible to increase the size of the journal so much that you would lose more by the increased size than you would gain by the perfection of lubrication; but I don't think that is the case in the description of the axle that we have considered. I think that there are very excellent reasons for believing that the lubrication of the journals in car axles is very imperfect; and the frequency of hot journals is a very sure proof that it is so, because if they were perfectly lubricated that would not be; the oil is partly pressed out between the brass and the journals so that the journal must heat. I believe the tendency has been to increase the size of the journal, getting as much bearing surface as possible. The subject is a practical one, and one about which the associate members feel some hesitation in speaking or in acting. There is this fact that the active members

must remembers, and, therefore, take such action as they think best; that the Committee is made up entirely of associate members; therefore I hope that practical men will tear the report to pieces as much as they know how.

Mr. PEDDLE, Terre Haute & Indianapolis Railroad—Mr. President, in our ordinary crank pins we put on a pressure of from eight hundred to one thousand pounds, and we do not have any trouble with the crank pins heating—no trouble about keeping them cool. I have no objection to increasing the length—that is, to a certain limit; if you elongate the journal too much, of course, you throw the center of the tire too far from the shoulder, and there is a liability to break that shoulder. There are, I find from what experience I have had, two circumstances to be taken into consideration. We have the rolling friction and the sliding friction. The rolling friction is the action of the wheel on the track; the sliding friction is the sliding of the journal on the box, and depends on the comparative diameter of the axle compared with the diameter of the wheel. If we have a car wheel thirty inches in diameter with a three inch journal, the sliding friction is one-tenth of the rolling friction, as the car rolling ten miles would slide but one. If you double that you slide that car two miles in running ten—that is, you double the friction, or double the resistance from friction; and I think if we go on and get the journal the size of the wheel and don't lubricate it, we will find it doubtful whether the wheels will not slide on the rail as easy as they slide on the journal. I think there is a limit to all these things, and I have made an estimate that this enlarging of the journal from three and one-fourth to three and three-fourth inches will take away from the hauling power of the locomotive something in the neighborhood of one car in twenty—from one to two cars in twenty. I think the locomotive can haul with smaller journals that much more than it can with large ones, if the axle is lubricated properly. The dead weight, too, is something that should be taken into consideration.

Mr. COLEMAN SELLERS, of Philadelphia—Mr. President, this question of friction in the journals is something that interests all mechanics, whether they are connected with railroads or not. The question of the size of the journal is one that comes fully into play in the making of all machines, and has received the attention of all those engineers who have had much to do with the construction of mill running and shafting. The rule that has been found to work best in such things is not to carry the journal up towards the size of the wheel—I think there is a decided disadvantage in that; but it seems to me that there is a certain proportion that should exist between the journal and the axle—that is, determined by the pressure of pounds per square inch upon the journal. I think this can be very well illustrated by little experiment that was tried a great many years in the city of Lowell upright shafts—that is, running on an axle running on its end instead of

journal—used to run upon a small point, say a mill of thirty or forty thousand spindles would have an upright shaft driving it which would have the end of its shaft three or four inches in diameter, and this run upon hardened steel plates that were lubricated. With this diminished surface came also diminished velocity, which is of course in favor of their running with less friction; but the diminished surface gave very much increased pressure, and the friction is in proportion to pressure and totally regardless of surface. What I mean to say by that is, if you have, say a brick, and you lay it on its flat side, attach a rod to it and drag it, you will find it requires a certain amount of power to drag this brick over the surface that it is placed on, and from that amount of power taken to draw it is derived the coefficient of friction. If you turn that brick up on its edge and the edge is only half the surface of the base, the friction is precisely the same in both cases, but the pressure is double in one case to what it is in the other, and the wear would be very much increased. Now, in reference to this question of upright shafts, which is a very good illustration of the point, Mr. Mason conceived the idea, as upright shafts had given a deal of trouble for a great many years, that he would, instead of decreasing the diameter of this bearing surface, increase it very considerably. He estimated the weight of the upright shaft, and after determining the number of pounds contained in that he divided it by fifty so as to obtain the number of square inches that would be necessary in the end of an upright that should have only fifty pounds pressure to the square inch. He then made a stop of cast iron perfectly plain on the base, with a square hole in it into which he let the shaftings. It was then placed so it would revolve in a square block of cast iron having a round face on it. This same block was prevented from turning by the box in which it set acting as a wrench to hold the block from running. He then drilled holes through the center of the block and into the middle of it to permit the oil to pass in and up into it. In the other block he cut grooves into the upper surface of it, so it would act as a pump drawing the oil and spreading it over the surface. Having proceeded thus far he builds it in one of the mill streams to try exactly what power he had. Mr. James had the system of upright shafts placed in his mills some twenty-five years ago—the upright shafts with these cast-iron stops run upon cast-iron bearings, lubricated in this particular manner that I have described. They were run continually without any intermission during a period of at least twenty years, when finally they determined to throw up this upright system and rebuilt the mill. At that time the stops were taken out, and I had an opportunity of examining them. During the twenty years' service of those stops they hadn't worn the tool marks off them. In other words, they had floated on a volume of oil which separated them entirely, and this reduced the friction to the friction due to the cohesion of the lubricant, and not of the

axle. It is exactly so in car axles; if you increase it to the extra size, you get it into a condition where this lubricant will, perhaps, act as a serious retardant; but if you increase it to such a point that the coefficient friction of the lubricant will not act as a retardant to reduce the pressure, you will, owing to the diminished friction of the thing, run easier on a big axle than you will on a small one which is constantly cutting itself or abrading itself away. There is this difference. If you reduce the axle to an exceedingly small size a single trip would wear that axle by the friction of one surface with the other; but if you increase it slightly in size, up to the point where the wear is at a minimum, then you will probably have the very best results. This I know to be the case in regard to mill shafts; as, for instance, an example that I have stated before—one that occurs in our own place, where the plate on the main shaft transmitting sixty-horse power runs upon a four and one-half inch journal that is twenty inches long. That journal has been run for twenty odd years, and last time it was examined, but a short period ago, the cast-iron box was polished only on one-third of its lower half of the box, showing that it had never worn into the box at all, and that is was never made to fit it perfectly; it was a loose fit and it only brightened that much of the surface, showing to us conclusively that the friction was diminished to the friction of the lubricant and not of the big journal. I think this is a very important subject; it is one in regard to which the associate members will feel some hesitation in advocating their views. It seems to me the acquaintance of some of them with the question of friction in other cases than car axles is one that would warrant their opinion to some consideration.

Mr. Fellows, Lake Shore & Tuscarawas Valley Railroad—I would say in regard to this large axle, from my experience I was as loth to go into it as any one could possibly be, for the very reason advocated here, that increasing the size must increase the friction. I could not see it in any other light; but after the statements in the Master Car Builders' Convention, and the arguments that were brought out there, and the recommendation they made to adopt the larger axle, we did adopt it, as I said before; to this time we have found less consumption of oils on these freight cars, a less frequency of renewals of brasses, and our engines haul just as many cars over the heaviest grades that we have, as they did before. When we first began to run them our engineers thought that these cars were going to be an extra trouble, and the conductors put off two cars from the trains. My attention was called to that fact to ascertain what was the matter with the engines, and in looking up the matter I found that that was the cause. I told the engineers I didn't want to hear any more of that at all; and from that day to this they have hauled their maximum over the road all the time, and they will do it with a majority of these large axle cars in the train—perhaps the train would never be entirely composed of them—and they go over the grade as fast as

they did with the other cars, from the fact that the experience of our car men all the time has been that they give them less trouble with hot boxes and oil is less frequently used. I am forced to the conclusion that there is more in that large journal than has been given credit for by the majority of people. Mr. Sellers' ideas in regard to it are simply what I have found by experience.

Mr. TOWNE, Northern Pacific Railroad—I will state that the St. Joe Company have been using on their locomotive trucks, journals five inches in diameter by nine inches long. Seven years ago one of these trucks was put under by engine there, which was about the first one that was put under—I think about seven years ago. In overhauling that engine and truck we found the journals not only perfectly strait and smooth and in perfect order, but the same diameter that they were when they were put under the engine with the exception of, perhaps, about three thirty-seconds of an inch wear. I made a statement to this Convention about two years ago in reference to these axles, and as near as I could ascertain at that time a great many of them had run one, two, and three years without any perceptible wear, perhaps from a sixty-fourth to a thirty-second of an inch in one year's time. Now I have always been inclined in favor of large journals since our experiments with those; and I am still in favor of large journals, and can see no objection whatever to them under any circumstances; on the contrary I see very much in their favor, more particularly since I moved from the St. Joe and took charge of another road, and have seen the difference between the running of the locomotive trucks under engines moving on the Northern Pacific, and those that they had on the St. Joe. Those of the Northern Pacific are of an ordinary size; the size that they use under nearly all the engines, perhaps, in the country, four and one-half by seven inches; a very fair journal, considered so at least, and I must say we have had a great deal of trouble with those journals. I have noticed it particularly, because we didn't have any trouble on the Hannibal & St. Joe Railroad with those large ones. We hardly run a trip without having a hot brass on the trucks on the Northern Pacific, whereas on the Hannibal & St. Joe I sent an engine out there new on one of these trucks, and she run eighteen months with the first boxes; the boxes of course, must be very large in order to accommodate themselves to that size journal; and I say again that we have no trouble with them—we don't know such a thing as a hot brass. So far as friction is concerned, of course we never can try that without a dynamometer; but in shoving the trucks around the yard I have certainly noticed, where I have had occasion to shove them myself, two men will move them about the yard very easily, and they move quite as easily as trucks with smaller journals. There is but one way of determining the friction, and that is by a process spoken of by Mr. Sellers, on the dynamometer method. So that I have no statistics in that direction. But another

word in reference to the use of these trucks, and that is the fact that every engineer on the Hannibal & St. Joe, with the exception of two or three, are now acquainted with the trucks, and the Company have been compelled to put them under the trucks for the reason that the engineers and engine men generally insist upon having them; they could not get along with the old truck, they must have the new, and since they got the new truck we had no more trouble. The truck is certainly built somewhat differently from other trucks, but so far as the style of truck is concerned I have nothing to say, as the journal is the same in either case.

Mr. CUMMINGS, Pittsburg, Ft. Wayne & Chicago Railroad—I would like to ask Mr. Towne how much weight he carried on those journals on that truck he speaks of?

Mr. TOWNE, Northern Pacific Railroad—Those engines are thirty-three ton engines, probably carrying from eleven and one-half down to nine tons. I desire to state in connection with this matter that on the Hannibal & St. Joe Railroad the journals of car axles were three and one-fourth by six inches, those under the cars of the Northern Pacific are three and one-half by seven inches; and I could not but notice a very marked difference in the running of the cars on the Northern Pacific than those on the Hannibal & St. Joe. We very seldom have a hot box up there, and the journals seem to wear very much better and smoother with less friction, for the reason that they don't wear so rapidly. They wear out very rapidly on the Hannibal & St. Joe Railroad; and I consider a three and one-fourth by six inches journal entirely too small for a car carrying ten tons weight; three and one-half inches is very much better, and I am decidedly in favor of a still larger one, although that is a very good standard.

Mr. CUMMINGS, Pittsburg, Ft. Wayne & Chicago Railroad—Mr. President, it seems to me that it is a very hard matter to decide on a uniform size and length of journal, unless we have some uniform weight of cars and engines. It seems to me that there must be some right proportion; but I can not see or understand why we should have as large an axle to carry two tons weight on as we should three. A journal that is of sufficient diameter to carry three tons would, it seems to me, be too large to carry two, as there would certainly be some loss in carrying that weight. As there are so many different kinds of cars, different weights of cars and engines, I do not see how it would be practicable to adopt the same journal on all roads.

Mr. FELLOWS, Lake Shore & Tuscarawas Valley Railroad—The argument is made that with the increase of journal more dead weight has to be hauled by the locomotive. That is very true in one sense; but if, as has been remarked, there is a better lubrication of the journal on account of the increased size it seems to me that the difficulty in the hauling by the locomotive is overcome. Another argument is that the extra weight involves extra expense in the building of those cars. That is very true, and can not be got

over. But the tendency in loading freight cars is to overload them rather than otherwise; and if the load is set at ten tons per car it is a very common thing to put on twelve if they can. Now, those cars that we have on our road, if they want to put on sixteen tons they can do it; they will carry it; and I do not suppose that we haul any cars that are loaded less than twelve, and more often they will go fourteen than twelve or eleven, and very few times will they be loaded as low as ten. The tendency on mineral roads particularly is to get all the weight upon a car you can; it is best to do it; so it seems to me that the better lubrication accomplished with the larger journal will overcome this difficulty of increased dead weight, to a great extent at any rate; and then with the increased strength there is the less tendency of breaking down from the breaking of the journal.

Mr. PEDDLE, Terre Haute & Indianapolis Railroad—If these gentlemen are right we have to destroy some of our text books; they all teach us different science entirely to what we have been taught here. This shows the advantage of having a laboratory to prove these things by actual experiments and tests.

Mr. JACKMAN, Chicago, Alton & St. Louis Railroad—There is one thing connected with these large axles that I wish to speak of. A good many years ago I saw fit to increase the size of axles under tenders, and I increased those at that time—that is, when I was in Ohio—to considerably larger than what was in general use. I did it, not to prevent heating, but to get absolute strength in the axles to prevent breaking. That is what I was most afraid of at that time; but then it is a well-known fact if you make an axle large you increase its weight, and that the wheels run upon the rail without any advantage of the springs. Therefore the more weight you carry the more you pound your track; yet I think that the size of the axle and the size of the journal should be in a great measure governed by the absolute strength that you want. It is safety from breaking instead of heating. For instance, in speaking of locomotive trucks, within two years past I increased the length of the bearings to some locomotive truck axles, they were seven and one-fourth inches and I increased them to eight and one-fourth inches, leaving the diameter the same—say four and one-half to four and three-fourth inches. Now, I don't think that I got any benefit, so far as the heating was concerned, by that increase of one inch in length. The experience I have so far as that is concerned, was over those that were seven and one-fourth inches in length being equal in diameter with the others. I continued to adopt that plan of eight and one-half inch journals, or what I call eight and a quarter inch, so that all trucks that I should build from that time forward would have that eight inch journal. Now, so far as this standard axle is concerned, I don't know that it is very much too large, provided the weight of cars is to be continued. If cars are to be made hereafter as heavy as they

are at present, and as they are making them, I think that the size of the axle adopted by the Master Car Builders' Association is about right; and if we are intending to adopt anything as a standard there are certainly reasons why we should adopt the standard they have adopted, because it might sometimes be handy to put a car axle under a tender, or a tender axle under a car, and in that case they would be interchangeable if made of the same size. The journal that is adopted is none too long nor too large. With regard to fitting the wheel we have it forged as near the size we want to use it as possible, so as not to waste any material. I have known several accidents to happen if care is not used. Every succeeding wheel that you put on the axle should be trimmed a little in order to make the wheel fit. I have never in my practice, no matter what the size of the axles were, been able to run over eighteen months or two years without wearing some off the journal. If the journals wear out the axles wear out to r certain extent. My experience is that you can't run a locomotive without wearing the journals that are in service on that engine.

Mr. HUDSON, Rogers Locomotive Works—Mr. President, this subject of the weight carried is very important, and with regard to the proportion recommended for the existing weight I don't think that the journal is at all too large. If I were going to recommend any change I would say make it longer. Some years ago we built some locomotives for the Erie Railway, and upon the trucks of these locomotives we made the journals ten inches long, whereas their ordinary journals were seven to seven and one-half inches; the diameter remaining the same of course. The consequence was that those journals gave no trouble. The brasses run two or three times as long as they did with the short journals, and I am told that they have given entire satisfaction, so much so that I believe they are introducing long journals in place of the shorter ones to a very great extent. With regard to tender axles, also where we have had to carry heavy weights, we have made journals as long as seven and one-half inches, and in one or two cases eight inches in length and of about the same diameter as recommended. I do not say that I think it would be well to increase the length much beyond that without increasing the diameter, because of the safety; other than that I am not in favor of increasing the diameter, except so far as safety from breakage is concerned.

Mr. J. S. FUNK, Northern Central Railroad—There is one other remark I would make, and that is the weight of the axles does not entail increased friction on the journal; that the mere weight of the axle does not make any more friction on the journal unless the diameter of the journal is increased; that the friction depends upon the load above the journal and not upon the weight in the axle, because I apprehend that while there is a rolling resistance to this weight it is very much less than that caused by the weight which it carries.

Mr. FORNEY, Railroad Gazette—I want to say, in regard to the diameter of the journals, that I concur with Mr. Peddle in regard to the question that the increase of the diameter is of itself an evil; but the difficulty is that you can not increase the bearing surface without increasing the diameter. When you had an axle that was, say an inch and a quarter in diameter, and which gave as much bearing surface as the one of Mr. Peddle, undoubtedly that would run with less friction than the one of three-quarters of an inch, but the trouble is you can not run a journal an inch and a quarter because it will break. In regard to what Mr. Jackman said, that the increased length did not cause diminished friction, is entirely due to the fact that the diameter was not increased in proportion to the length, and consequently the axle would spring, and the bearing would not be equal. If you want a bearing surface on a car journal you are obliged to increase the diameter in order to get the requisite strength. If you could get a bearing surface on a journal three and a quarter inches in diameter, and have a sufficient strength of axle, undoubtedly it would be an advantage; but in order to get the length of seven inches, it was thought that no smaller diameter than three and three-quarter inches would be sufficient.

Mr. PEDDLE, St. Louis, Vandalia, & Terre Haute Railroad—I suppose the argument is that the larger the journal the less the friction is. I don't make that clear in my mind. I know, in the old time, when we had our grindstones, they used to say it helped to have friction wheels under the journal; and the principle of that is the reducing the size of the journal, and increasing the ease with which the stone is turned.

Mr. HUDSON, Rogers Locomotive Works—I will state, in reference to some of the cars built expressly for carrying locomotives, where the journals are four and one-quarter inches in diameter by nine and one-half inches long, if we could make them longer without increasing the diameter we should be willing to do it.

Mr. SELLERS, of Philadelphia—In reference to what has been said with regard to the using of friction rollers, there the question is not of diameter or size in a great degree. The bearing is taken upon four rollers instead of two; but it is the diminished velocity of those journals that decreases the friction. They run so much slower. The larger the carrying wheels are in proportion to their journals the better strength given to them; the better support enables the friction to be diminished. There is a gentleman near me who spoke about the size of the different axles suited to different work; that if it were possible to arrange the axle to suit the particular work that it has to do there is no question but what it would be advantageous to have large axles and small ones on the same road. But the question seems to me to be the adaptability of one axle to do various kinds of work, as the general load attached to cars and to tenders does not vary very materially, and that the standard axle that shall be used should answer the various purposes for which

axles are required would be an advantage and facilitate their manufacture.

Mr. Wells, Jeffersonville, Madison, & Indianapolis Railroad—I presume that so far as the size of the journal is concerned, and the length of time it will wear without materially changing its shape, the size adopted by the Master Car Builders, perhaps, is better than a smaller size. But the question, it seems to me, would be whether the increased expense in putting axles of that size under cars, whether the advantages will compensate for that increased expense. Now, we can't make a journal three and three-quarters of an inch in diameter without making an axle about four and seven-eighths of an inch in diameter in the wheel; and it seems to me that in a very large majority of cases four and seven-eighths of an inch axle is larger than is necessary to carry the loads upon the cars. We know that cars are run one-third of the time, perhaps, on an average, empty; and, perhaps, a good portion of the other time not loaded to their full capacity; and the question arises, wouldn't it be better to have an axle of smaller size; for instance, four and one-half inches in diameter in the wheel—wouldn't that be better in the majority of cases, if not in all cases, than the large axle? I will admit that the three and three-quarter inch journal, perhaps, would give better satisfaction than the three and one-half inch journal; but yet the disadvantages arising from the heavy axle—the increased cost, the increased dead weight—will not they be a sufficient offset to the advantages derived from it?

Mr. Forney, Railroad Gazette—The one consideration that has to be taken into account, was what my old employer used to say when I was an apprentice. He used to say to his boys: "If you make a thing too strong nobody will ever find it out; but if you make it too weak you will soon hear about it." Now, absolute safety is the thing to be taken into account here. I have no doubt, in many cases, a lighter axle will do very well; but to meet all the various circumstances it was thought it was necessary to adopt an axle as large as was adopted in order to be perfectly secure under all circumstances.

Mr. Elliott, Ohio & Mississippi Railroad—In my judgment you gain as much by increasing the size of the axle to the full size as you do by increasing the journal. In my judgment I have suffered more from my axles being made too light, as Mr. Lilly said in his remarks, and as illustrated by Mr. Jackman in his remarks, he gained nothing by increasing his length, because he didn't increase the diameter. Mr. Towne, in his remarks, gained everything by increasing the diameter; but, at the same time, he increased the size and reduced the spring of his axles; and there is where I think a great deal of our trouble has come—not so much from the size of the journal as from the spring having more weight put on it than it would carry. This, I think, is a very important point to be considered. Now, I believe, if we had an axle made the same size as the standard axle, turned down to three and

one-half inches, we would get about the same results we get from three and three-quarter inches; but I prefer the three and three-quarter inches, leaving the iron and have it worn down to the size rather than turn it off. I like the size that has been adopted, and think it will do very well for the purpose.

Mr. FORNEY, Railroad Gazette—I would like to suggest that it seems to be necessary to take some action in regard to this matter. I believe there was no motion made in regard to adopting this standard, and I think some action should be taken in regard to it.

Mr. JEFFREY, Illinois Central Railroad—I would suggest before any action can be taken adopting the standard, it will be well to find out what would be the proper pressure per square inch on the journal bearings. Mr. Sellers has given us certain facts with regard to the wearing of an upright shaft having a pressure of fifty pounds per square inch of bearing. Experiments might be made with different-sized shafts or axles; and I have no doubt the matter could be investigated by a committee giving the results of different weights per square inch of the bearings; and I think that would be the proper course to pursue to ascertain definitely as to how much area will be best for a given weight of bearing before action is taken. I was figuring over roughly about the weight per square inch of bearings on axles in use on the Illinois Central road, and I found that on the four and a half inch journal—and that is the standard all over the road—the weight per square inch of journal bearing would be 148 pounds, provided you had a bearing equal to one-half the diameter of the axle. The probabilities are the bearing would not exceed one-third the diameter of the axle, which would materially affect the point. With a half-inch driving-wheel it would be 138 pounds to the square inch generally; that is, provided you had a bearing equal to one-half the diameter. That again would be modified, of course, by the bearing being only one-third; and on loaded freight cars carrying thirty tons it would be 160 pounds, with the same proviso as I have before mentioned. On a sleeping car, taking the weight at twenty-seven tons, a twelve-wheel car, and the thirty passengers at three tons, we have in round numbers thirty tons, and the weight per square inch of journal bearing with the three and three-quarter inch axle, which is the standard, would be about 160 pounds. That again would be modified by the proviso I have mentioned. Add, say one-third, to each of these calculations, will make in the neighborhood 200 pounds for a four and a half engine truck axle, and in the neighborhood of 180 pounds for a six and one-half inch driving axle, and in the neighborhood of 220 pounds each for a freight and sleeping car per square inch of the journal bearing.

Mr. SELLERS, of Philadelphia—In reference to the question of friction, and the sizes of parts adapted to support the friction, mechanical engineers have to take into consideration two questions, one of velocity and the other

of pressure; and it is necessary to consider it in both relations before they can decide upon the size. The facts that are in possession of the profession already are such, that, knowing the velocity, and knowing the pressure, it is perfectly possible to so arrange the sizes of the parts that the friction shall be reduced to the minimum while the wear will be the maximum; but the amount of pressure the bearings will sustain under different work varies all the way from fifty pounds up to 7,000 pounds per square inch. When you are screwing up a nut with a three-quarter ihch bolt with a twelve-inch wrench, at the time you fail to screw that up any more, you have obtained a pressure of 7,000 pounds on a square inch. I have tried that by actual experiment. That shows that it is possible, in some instances, to run an iron at a pressure of 7,000 pounds a square inch, but you must run it very slowly. It is a question of velocity as well as pressure. On modern engines the question is one that is continually interfering with success. The pressure on crank pins is so great that in many of the engines they have to have a system of cooling down by water to preserve them from cutting, and their common pressure is about 800 pounds to a square inch; and still they do pretty good work with it. But I think that if we could adapt the axles to the particular work they have to do, and make each one properly suited to that, it would be a great deal more economical in practice than having one particular axle to do all kinds of work. But now the question is whether one standard axle could be advantageously employed on these different kinds of work.

Mr. TOWNE, Northern Pacific Railroad—I heartily concur with what Mr. Jeffrey said in reference to the journals. I do not believe in adopting anything without evidence, and we certainly have no evidence that the size named is the best journal for cars; no more than you have evidence that four and a half by seven inches is the best size for locomotive trucks. Now, sir, I believe that the subject rests upon experiments, and without experiments we don't know what we are doing. I would not vote for the adoption of that axle, or that sized journal, without testing by experiments, and thus ascertaining what we want for that amount of weight.

Mr. ELLIOT, Ohio & Mississippi Railroad—I have heard a good deal of discussion as to what I said when I got up before. I believe, sir, that very much more depends on the size of the axle inside of the wheel than it does upon the journal. I concur with Mr. Peddle that the journals of crank pins does not heat, because they are held firmly and solidly by the wheel. There is no spring there; there is no tumbling about; but where you have an axle that is very slight in the center pounding up and down all the time, the journal tipping about, it creates a very great deal more friction than it would if that axle were stiff and held firm and rigid. I concur with Mr. Forney again when he says that if we had the strength without increasing the diameter, we would arrive

at this point, because, as you increase the diameter you increase the speed, and with the speed the friction must be increased. But if you can overcome that by lubricants between the two—if the surface is large enough so they would not be pressing together, you overcome that excess of friction. I concur again with my friend from the Northern Pacific Railroad, that this is a subject for experiments, and I think if these experiments were carried on to ascertain at what point you made the axle stiff enough, so that there is no springing, you would find that you would require a very greatly increased journal.

Mr. Johann, late of Canada Southern Railroad—I don't think we are prepared to vote on axles this session. If we did vote I don't think it would amount to anything. About two years ago I was connected with a new road just started, and I prided myself that I had a chance then to get something that would be uniform; and I wrote to the most prominent of our railroads, inquiring about the wheels they were using, and what they thought were the best to use. I got about as many answers as questions asked, of the different roads, and each differed in opinion. I made these inquiries for the purpose of getting a uniform axle. I was pretty well satisfied in my own mind as to what I would like to have, but still, I would have preferred to adopt that axle which would be generally or universally adopted. During my correspondence the Committee of the Master Car Builders published their opinion of what they were going to report for adoption at their next session, and I concluded that it was just about what I wanted, and would probably be adopted by the road I was connected with. And it was so adopted. That size was three and one-half by seven inches. At their meetings they overhauled the whole question, and adopted three and three-fourths by seven inches. That left me outside again. I concluded then I would go ahead on my own experience, and let the others do the best they could. I think we are wasting very valuable time in the discussion. I move that the subject be referred to the old Committee for consideration during the coming year.

Mr. Hudson, Rogers Locomotive Works—I second the motion, and at the same time would suggest that the question of the dust be not forgotten, as it is a very important question in the heating of car journals.

Carried.

The President—The next business in order will be the report of the Committee on "Continuous Train Breaks."

Mr. Chapman, Cleveland & Pittsburg Railroad—I move that when we adjourn it be to meet this evening and to hold an evening session, and request the President to fix an hour.

The President—I would suggest eight o'clock.

Adopted.

Mr. HAYES, Illinois Central—I move a committee be appointed to select a place for the next meeting, and report to the Convention this evening.

Motion carried.

THE PRESIDENT—I will appoint on that Committee Mr. Reuben Wells, of the Jeffersonville, Madison, & Indianapolis Railroad; Mr. Garfield, of the Providence, Hartford, & Fishkill Railroad; and Mr. Robinson, of the Great Western Railroad of Canada.

The Secretary then read the report of the Committee on Oils for Locomotive Use.

Report of the Committee on Oils.

To the American Railway Master Mechanics' Association:

GENTLEMEN—Your Committee, appointed to examine into and report on the subject of the "Best Lubricant for Cylinders and Other Machinery," beg leave to submit the following:

Your Committee prepared and issued, through the Secretary, three hundred circulars, containing the following questions:

1. What is the best lubricant you have used on valve seats and cylinders of locomotives? Please state your preference and your reasons therefor?

2. Have you ever used any mineral oils, or mixture of plumbago, that you can recommend as superior to tallow or extra No. 1 lard oil?

3. In your opinion does the use of hard or soft water materially affect the value of tallow or oil as a lubricant, and if so, why?

4. What kind of oil do you prefer for general use on locomotive bearings? If a mixture, how is it prepared, what are the ingredients, and what is the average number of miles run per pint or quart?

5. What method do you regard the best for oiling valves, the self-feeder, or the old plan of oiling with a can at regular intervals?

6. The Committee will be glad of any other information you may impart on the subject of oils for rolling stock, and especially journal bearings of cars.

Not so large a number of answers have been received as might have been expected from the importance of the subject; but your Committee feel less disposed to find fault with the *number* than the character of information contained in most of the answers received.

Committees are not suddenly invested with a superior knowledge on account of being appointed to investigate a subject, as the monosyllable answers to questions by some members would seem to indicate, but they must depend on the information received through their circulars for material on which to base a report, and *yes* and *no* furnish but little.

The majority of replies in answer to the first question of your Committee favor the using of the best extra lard oil for lubricating cylinders, and give as a reason that it contains less acid, and is less liable to waste away the iron than tallow or tallow oil. Prominent among these may be mentioned Mr. Boone, of the Pittsburg, Fort Wayne & Chicago Railroad. He says: "I consider the best lubricant for cylinders and valve seats to be the best No. 1 lard oil that can be obtained. I have never had any trouble from iron wasting away from the use of lard oil, but I have with tallow. There is some kind of a chemical action takes place when tallow and steam come in contact, whereby an acid is formed that will destroy cast-iron, making it so soft that it can be cut with a knife. When using tallow I have frequently had steam chests and cylinder faces ruined from this cause, and have never taken up a steam chest or cylinder head that new joints had not to be made; but with lard oil these joints last for years. Have not had to plane off a steam chest or cylinder-head joint for five years."

The above statement, coming as it does from one of the leading roads of the country and supported as it is by a majority of Master Mechanics, is a strong incentive to your Committee to recommend the use of extra No. 1 lard oil, to the exclusion of everything else, for a cylinder lubricant but while, as has been stated, a majority favor its use, your Committee do not feel like ignoring the opinions of the minority, whose experience is at variance with that of Mr. Boone and others, and who positively assert that both lard oil and tallow waste away and destroy the iron of steam chests and cylinders badly, and that *sperm oil* is the proper lubricant, but would suggest to such members the possibility of the quality of the iron having something to do with the action of the oil, and *vice versa.* In either case the truth is worth finding out. The difference between facing joints every time they are broken, and only once in five years, is too

great to be lost sight of by mere mention in a report, and your Committee hope to hear the matter fully discussed in open convention.

To the second question of your Committee there seems to be but one opinion. Notwithstanding, a number report having tried mineral oils, all are unanimous in condemning them for use in cylinders of locomotives. A number of Master Mechanics report good results from a moderate use of plumbago on new valve faces and cylinders, it having a tendency to make a smooth, polished surface, and thus secures the easy working of the valves.

To the third question, "Does the use of hard or soft water materially affect the value of tallow or oil as a lubricant, and if so, how?" opinions are about equally divided. There is, however, a very notable difference in the answers of those who deny any bad effect from the use of hard water, and those who are of the opposite opinion. With only one or two exceptions the answers of the former are "No," without giving any reasons, while the latter class are disposed to back their opinions by argument.

Mr. Hayes, of the Illinois Central Railroad, maintains that where hard water is used the oily matter will not last so long in cylinders and on valve seats. Owing to the alkali contained in the water the oil is practically converted into soap, which the heat soon destroys.

Mr. Boone thinks hard water destroys the value of tallow as a lubricant, and assists the injurious chemical action heretofore referred to in its use, but does not think it will injuriously affect lard oil.

Mr. Sedgley, of the Lake Shore Railroad, finds that a much larger quantity of oil or tallow is required for lubrication of valves and cylinders where hard water is used.

To the fourth question, as to the kind of oil preferred for general use on locomotives, a majority report in favor of lard oil and paraffine. Five are using West Virginia oil with good success, although preferring sperm or lard oil. The average number of miles run to a pint of oil is twenty-eight.

As to the best plan of oiling cylinders, a majority favor pipes leading to the cab as being the safest for employees, and the most reliable method in use. Four prefer the self-feeder, and five the old plan of oiling from the cab.

Mr. Hayes, of the Illinois Central Railroad, remarks of the self-feeders: "These would, undoubtedly, be the best if we could get an automatic man to work it, but as we can not get such a machine, I think the next best thing is to oil from the cab."

Thus your Committee has given you the substance of the evidence they have had before them bearing on the subject of lubricants for cylinders and other machinery of locomotives, and it now remains for the Committee to weigh the evidence and present their conclusions for your consideration.

Your Committee would therefore respectfully recommend the use of extra No. 1, or the best grade of lard oil as a lubricant for cylinders, believing that their own experience, and that of a majority of Master Mechanics, fully warrant them in saying it is better than tallow, and far superior to any mixture or combination of mineral oil gotten up for that purpose.

In the opinion of your Committee there has been no evidence presented to show that the use of hard water has any injurious effect on the value of lard or tallow oil as a lubricant, other than the fact that with hard water a greater quantity of oil is required. Of this there is no doubt. The alkali dries up the oil and is, thus far detrimental.

The theory that an injurious chemical combination is formed that destroys the iron, your Committee believe to have sufficient merit to demand a careful investigation.

For general use on locomotive machinery, your Committee would recommend No. 1 lard oil.

The best method of oiling valves is, in the opinion of your Committee, to have pipes running to the cab, and supplied with suitable cocks to blow through with steam. This plan relieves the fireman from any danger in oiling; is reliable, and can be so arranged as to accurately measure the oil, and thus reduce the quantity used to the smallest possible amount that will accomplish the purpose.

For journal bearings of cars, your Committee recommend for freight, pure Virginia oil, of not less than twenty-eight degrees gravity, and for passenger car service No. 2 lard oil, as giving very good results; and we would further recommend that great care be

taken to make oil boxes tight, having a close-fitting cap in front, and good leathers back, as being necessary to exclude the dust.

All of which is respectfully submitted.

J. JOHANN, *Toledo, Wabash & Western R. R.*,
W. B. SMITH, *South Carolina R. R.* } *Committee.*

The report was accepted.

Mr. HAYES, Illinois Central Railroad—I move that we now adjourn.

The motion was carried, and the Convention adjourned to meet at the Sherman House at eight P. M.

EVENING SESSION.

SHERMAN HOUSE, THURSDAY, *May* 14, 8 P. M.

The Convention met pursuant to adjournment, President Britton in the Chair.

THE PRESIDENT—Gentlemen, when we adjourned to-day, we had just finished the reading of a report on Oils for Locomotives. The subject of that report is now open for discussion. If there is nothing to be said on that we will proceed with the business next in order, which is the report on Continuous Train Brakes.

Mr. WELLS, Jeffersonville, Madison, & Indianapolis Railroad, the Chairman of the Committee on Continuous Train Brakes read the following report:

Report of Committee on Continuous Train Brakes.

To the American Railway Master Mechanics' Association:

GENTLEMEN—Your Committee on "Continuous Train Brakes," appointed at your last annual meeting, issued a circular for the purpose of eliciting information on this subject. The interrogatories set forth therein were as follows:

1. In your opinion, what are the requirements in a power brake to produce the best results and necessary to accomplish the end desired in the most perfect manner?

2. Are you using a continuous brake on the equipment on your road? If so, what kind, and by what name is it known?

3. Is it efficient and reliable under all ordinary circumstances; and in its action and results is it all that is to be desired? Do you know of instances where, in your opinion, the use of this brake has been the means of saving life and preventing serious destruction of property? If so, please relate the circumstances.

4. Will the brake you describe remain set on all the cars after being applied, even if the train should become severed by accident?

5. Do you consider the feature referred to in the fourth question a matter of vital importance, as a means of preventing—at least in many cases—serious results in the destruction and injury that so frequently attend accidents of this character?

6. Do you know of any brake that will apply automatically in case the train should become severed, or any part of it thrown from the track? If so, please give a description of the device.

7. Do you consider a brake having the above automatic attributes of sufficient value and importance to warrant its general adoption?

8. Have you in use, or knowledge of, a power brake applied to the driving wheels of locomotives? If so, give a description of the same, and your opinion as to its merits, with your reasons therefor, for or against such application of braking power.

9. In your experience is the brake, when thus applied to the driving wheels, found to be destructive or injurious to the several parts of the locomotive affected thereby?

10. If found to be injurious, what proportion does such extra wear and the cost of repairs bear to the benefits derived therefrom?

11. If the application of brakes to the driving wheels of locomotives hauling passenger trains is desirable, would the results, in your opinion, be equally beneficial if applied to those hauling freight and other trains, and those doing switching service?

12. In your opinion can a road be as safely and economically operated, all things considered, by the use of hand brakes, or a similar braking power, as by the use of a good system of continuous brakes; and will not the advantages derived from their use more than compensate for their original cost and maintenance in good and perfect condition thereafter?

To the above circular we received replies from twenty different Master Mechanics and Superintendents of Motive Power on the Rail-

roads of the United States and Canada. Of this number three use only the hand brake on their passenger equipment, one uses in addition to that the Creamer Brake, fourteen are using the Westinghouse Air Brake, and two the Smith Vacuum Brake.

The replies, with two or three exceptions, give but little additional information to that furnished by the report of the Committee on this subject made to you at your last annual session.

There is but little difference of opinion, as to the requirements of a train brake, in the minds of well-informed persons having experience in the management of trains running at high speed. The requirements are, namely:

1. Certainty of instant application to all or as many of the wheels of the train as practicable.

2. The retarding power should be capable of being graduated at the will of the person applying it, under all ordinary circumstances.

3. When applied, from any cause, it should so remain until the train is brought to a stop, unless persons in charge of it desire otherwise, in which case it should be capable of instant, partial, or total release.

4. The brake power should be under the control of the engineer of the train. It should apply itself automatically in case of derailment of any part of the train, or in case the train should part accidentally, and should be capable of application from any car in the train.

The above being the main points in the requirement of a theoretically perfect brake, the question for consideration is, how near are these requirements fulfilled by the best continuous train brakes yet brought to public notice?

The system of running trains in this country, the character of the country through which they run, and the causes so frequently occurring, requiring quick stops to be made at unlooked-for times and places to avert danger, imperatively demands the adoption on all trains conveying passengers, running at high speed, some good system of continuous train brake, embracing in the main these features A long list of the different kinds of continuous brakes, which have been tried on the different roads in this country during the past

twenty years could be given, but as the greater number have been abandoned, reference to them is unnecessary. At the present time two classes only seem to give promise of fulfilling the requirements of a brake approaching perfection, namely, the one using compressed air as a means of applying the brakes; the other, a vacuum. Of the former class, that known as the Westinghouse Air Brake is the only one that has so far come into general use. The Gardiner & Ransom Brake, in some respects a duplicate of the Westinghouse, has been tried on several roads, but it has not, as yet, met with general favor.

The Loughridge Air Brake, in some respects also similar to the Westinghouse, is now being applied to the passenger equipment of the Baltimore & Ohio Railroad and the lines under its control, and up to the present time about forty-five locomotives and one hundred and fifty cars have been equipped with this style of brake.

The Westinghouse Air Brake, up to the present time, has been applied to 2,232 locomotives, and about 6,900 passenger, baggage, and express cars, on 141 different railroads (not counting branches) in the United States and Canada; on 66 locomotives and 448 cars on sixteen different railroads in England, Scotland, Wales, Belgium, and in South America, Cuba, and Mexico.

Of the roads that reported to your Committee, two have adopted the Smith Vacuum Brake, viz: the Central Railroad Company of New Jersey, and the Hartford, Providence & Fishkill Railroad, and the Old Colony Railroad, of Massachusetts, have it on one engine and four cars, but use the Westinghouse Brake on the balance of their passenger equipment.

The Vacuum Brake has been introduced on a number of other railroads, principally in the Eastern States, but which have made no reports to your Committee of its operation.

For reasons before stated we propose to consider some of the points of difference in those brakes using compressed air as a motive power, and the vacuum brake. Under the head of Compressed Air Brakes are included:

1. Those in which the power for compressing and storing air acts independently of the movement of the locomotive; and,

2. Those in which the air pump is operated from an eccentric, or some other reciprocating part of the locomotive, so that the opera-

tion of the air pump is governed entirely by the movement of the locomotive.

The present Loughridge Air Brake belongs to this latter class. The advantages of a brake having the attributes of independent motion, and capable of action independent of the movement of the locomotive, other things being equal, are too obvious to need explanation. Yet, in point of simplicity, so far as the driving power to the air pump is concerned, the advantages are on the side of the air pump that is operated from some reciprocating part of the locomotive. But little, on the whole, can be claimed on the score of economy by this method of compressing air over that of an independent air pump, for the reason that when running, and the pressure of air in the reservoir is at the maximum point, the pump is constantly delivering air into the reservoir, against that pressure, in nearly the same quantity at each revolution of the wheels of the locomotive, after the desired pressure in the reservoir is obtained, as before; and power is thus expended in pumping more air than is needed, during the time run in which no air is used in applying the brake; and an automatic compensating arrangement of the pump, so as to pump air only when the pressure falls below the maximum point, would complicate the machinery perhaps to the extent of an independent pump, in which event nothing would be gained in that particular, even, and to close the passage between the pump and reservoir, and allow the air from the pump to escape by means of a three-way cock, would require more attention from the engineer than could at all times be given. So far as the air pump itself is concerned, with its valves, pipes, and connections, nearly the same parts are required when driven by the locomotive as when by a separate steam cylinder.

The above objections may, however, be considered of but little consequence, yet there are others to the arrangement of compressing air by a pump driven from some reciprocating part of the locomotive, and dependent on the movement of the locomotive for action, which seem to your Committee of a more serious character, and to which we direct attention. Where long runs are made, and stops not likely to be frequent, after the train is started, and the requisite pressure of air in the reservoir is attained, but little, if any, diffi-

ulty would be experienced in keeping up the requisite pressure of ir in the reservoir necessary to make all the usual or ordinary stops, et circumstances are likely to arise when a sufficiency of air could ot at all times be supplied by this method. Trains on railroads entering in the larger cities, passing in and out through the yards, nd over the numerous switches, and over the crossings of other oads in and about such cities, and not unfrequently over draw-ridges, find it necessary to apply the brakes as many as a dozen mes within the distance of one or two miles, and at such times nd under such circumstances that render the quick and certain ction of the brakes of vital importance. In practice it has been ound impracticable to entirely prevent all leakage of the joints of e pipes, connections, and other parts subject to the pressure of the ir, and this, added to the air required in making numerous stops ithin a short distance run, would in many cases, especially with a ng train of cars, reduce the air pressure in the reservoir to such n extent as to render the brake inefficient, except perhaps when the ir pump and the reservoir were disproportionally large.

Another objection urged to this manner of driving the air pump the fact that while the stop is being made, and the consequent eduction of air pressure in the reservoir occurs, the speed of the ocomotive decreases, and as a consequence there is a corresponding ecrease in the quantity of compressed air delivered in the reser-oir, and as the train comes to a stop, the air pump stops also, and hus the decrease in the supply of air to the reservoir takes place ust at the time when it is important that it should be kept up.

In this mode of compressing air it will in many cases be found ecessary to run the locomotive a short distance previous to starting rith the train, for the purpose of pumping up air, if it is desired to ave a supply in the reservoir at the time of starting, unless the eservoir is filled from a stationary one at some convenient place, reviously charged for that purpose, which would add to the cost of working the brake.

It is probable that more or less difficulty would be experienced in keeping up the air pressure in the reservoir when standing still, for any considerable length of time, as when waiting at meeting sta-tions for other trains, or when from any cause a stop is made re-

quiring more time than that allowed in making the ordinary stop at way stations. These are some of the objections that occur to us will be urged against this method of compressing the air required to operate the brakes.

As a compensation for the disadvantages that might arise from the method adopted by Mr. Loughridge for compressing air, he uses proportionally a larger reservoir, and the air in it at a higher pressure, than those using an independent air pump, and in connection with the reservoir a graduating valve, by means of which the engineer can regulate the pressure of air admitted to the brake cylinders of the train at will. This valve being automatic in its action, admitting to the brake cylinders the pressure to which the valve is adjusted, and no more, and maintaining the pressure at that point as long as that in the reservoir does not fall below that at which the valve is set.

Where a pump is used that is independent in its movements, regardless of the movement or speed of the locomotive, a supply of air can always be kept in the reservoir for all emergencies that may arise, regardless of the number of stops made, or applications of the brake within a given time, or distance run by the train.

Another advantage of an independent air pump is that the speed of the pump can be suited to the quantity of compressed air required, and that when the maximum pressure is attained in the air reservoir, the movement of the pump will be slow—sufficient to keep up the required pressure and no more—and when the pressure in the reservoir is reduced, from an application of the brakes or otherwise, the movement of the pump becomes more rapid, and as a consequence quickly restores the original pressure in the reservoir, thus supplying the braking power as it may be needed and for every emergency.

In the above we have only brought to your notice the difference in the two methods of compressing the air furnishing the brake power, viz., that depending on the movement of the locomotive, and that acting independently, and in our opinion the latter method has advantages over the former that outweigh the objections urged against it on account of the additional, and, to some extent, complicated steam power requisite to work the air pump.

As stated before, on account of the various continuous brakes that have been tried and abandoned as worthless up to the present time, leaving only two systems now in use on any considerable amount of rolling stock, we propose only to call attention to the difference between the system where compressed air, previously stored, is used to furnish the braking power, and that where a vacuum is made use of as a means to accomplish this object.

It is but just to ourselves to state that in our efforts to obtain valuable and reliable data in regard to the mechanical arrangement and working of the vacuum brake, we have to a very great extent failed.

The principle upon which this brake is operated is doubtless well understood by a large proportion of persons familiar with train brakes, yet we think it proper to give some general description of this plan, as there may be persons interested in this subject who are not familiar with the principle and working of the vacuum brake.

From the ejector, situated at some convenient point on the locomotive, a tube of suitable size extends under the tender and under each car in the train, the ends of the tubes between the cars, and between them and the tender, are connected by hose with suitable couplings so as to permit the free motion of the several parts of the train without breaking the connection, forming one continuous tube from the ejector to the rear end of the train. To this tube, at some convenient point under each car and tender, is attached a cylinder with a movable piston, or a cylinder made of a series of elastic diaphragms, say twenty inches in diameter, and when extended about two feet long, having rigid heads, one of which is connected with the tube passing under the car by a flexible pipe or hose, making a connection between the tube and inside of said cylinder. This cylinder is so constructed that it is capable of moving in but one direction, the ends or heads approaching each other, thus shortening it by producing a vacuum within it. To these heads or to the movable piston, when an iron cylinder is used, is attached the connections by which the brake is brought to act upon the wheels.

The ejector attached to the end of the tube at the locomotive is, in principle, the same as that used and commonly known as an *injector*. Suitable pipes and valves connect this ejector with the

locomotive boiler. To apply this brake it is only necessary to admit the steam from the boiler to the ejector, which, flowing through the annular opening of the nozzle outward into the open air, *drags* or *pulls* the air from the tube extending under the train, by the friction of the steam upon the air surrounding and inside of the annular jet, as it passes the smallest part of the opening in its rapid passage outward, and thus producing a partial vacuum in the tube extending the length of the train, and consequently producing in each of the brake cylinders a vacuum to the same degree as in the tube, thus causing the heads of the cylinders referred to to approach each other, in effect to shorten the cylinders, and by this means apply the brakes to the wheels by the connections referred to above. Suitable cocks and valves are arranged in the tube at the ejector for preventing the return of the air into the tube, or for admitting the air, in order to graduate the force with which the brake is applied, or for releasing it, which always takes place when the air is allowed to flow back into the tube and cylinders. The force or power exerted in applying this brake, depends upon the extent of the vacuum produced in the tube and brake cylinders of the train, other things being equal. It is found in practice that a vacuum of from eight to nine pounds per square inch is all that can be depended upon in the practical working of the brake, therefore the diameter and length of the cylinders must be proportioned to suit the maximum power intended to be exerted in applying it to the wheels. In point of simplicity in the number of parts this brake has the advantage, in that particular, over all others now in use.

In regard to the working of the vacuum brake, Mr. T. W. Peeples, Mechanical Engineer of the Central Railroad of New Jersey, upon road which this brake has been adopted, in answer to our circular states: "It is efficient and more reliable than any brake I know of; the results are very satisfactory, indeed. I have heard of several instances whereby accidents have been prevented by the prompt use of the brake, but I have no data or record of the circumstances."

Mr. E. Garfield, Master Mechanic of the Hartford, Providence & Fishkill Railroad, in his reply, states that in their experience with the vacuum brake on that road, they have found it to be efficient and reliable under all ordinary circumstances; and, further, in reply to

question third: "I have no record, nor do I remember of any case where this brake would have prevented accident that *other* good brakes in order, and properly used, would not have prevented. The parties referred to above make no statement, nor do they give an opinion as to the comparative merits of the two systems of continuous train brakes."

Mr. J. K. Taylor, Master Mechanic of the Old Colony Railroad, states in his reply, that on his road about twenty-five locomotives and one hundred and twenty cars are equipped with the Westinghouse Compressed Air Brake, and one locomotive and four cars with the Smith Vacuum Brake, and that on one occasion a passenger train equipped with the Westinghouse Brake was stopped within forty feet of a crossing over which another passenger train was passing at the time, and that the stop was made in a distance run of five hundred feet, from a speed of twenty-five miles per hour; and adds: "I do not think it could have been done with the vacuum brake;" but gives no reason for such opinion. Yet the inference is that it was formed from his observation of the workings of the two systems.

If the train referred to above could not have been stopped within a distance of five hundred feet, from a speed of twenty-five miles per hour, by the vacuum brake, the question would naturally arise, why this difference?

With the vacuum brake the flow of air is outward from the tube and brake cylinders, and as the air flows out, less of it in a given time comes in contact with the jet of steam flowing out through the ejector, as the vacuum in the tube becomes nearer perfect, so that more time is required to increase the vacuum from eight to nine pounds, than from seven to eight pounds, and more time from six to seven pounds than was required to increase the vacuum from five to six pounds per square inch. In other words, each additional pound of a vacuum per square inch requires a longer time to produce it than was required to produce the one preceding it.

The value of a brake depends, to a very great extent, upon its capability of instant application. For instance, if it required eight seconds of time to produce the requisite pressure on the shoes to the wheels in one system of a continuous brake, and but four seconds to accomplish the same in another system, the latter would be vastly

more valuable than the former; time being, in such cases, a matter of vital importance. In practice it is found that not more than about sixteen seconds is required to bring a train to a stop on a level track, from a speed of thirty miles per hour, and even less time is requisite under favorable conditions of the rails. Now, it can readily be seen how important it is that the maximum force required upon the brake shoes should be attained in the shortest space of time possible after the brake is applied; and if, by the system of compressed air previously stored, this end can be accomplished, then this system is, to that extent, the best. Your Committee addressed a letter of inquiry to the President of the Vacuum Air Brake Company, requesting some data in regard to the working of that brake, but failed to obtain any from that source, consequently such information as we have was obtained from other sources, and the opinions of those using it. The opinion, so far as we can get it of such parties, is, that this brake is slow in its action compared with that of compressed air previously stored.

In the vacuum brake the power must be generated *after* the brake is applied, while in the compressed air brake the power or force is *previously* stored, and to apply it is, in effect, the same as to relieve a spring of the force holding it in tension; while, in the vacuum brake, the power as it is generated for use is, in principle, the same as a spring taken at rest without load, and then *bringing* it to the tension requisite to give the brake the power required.

The vacuum produced in practice being but about eight or nine pounds per square inch, consequently the brake cylinders must be of great area to give the required power, and the *volume* of air to be removed from them on an application of the brakes is correspondingly large.

With air previously compressed at a pressure of, say sixty pounds, and used in the brake cylinders at forty-five pounds, the *volume* of air at that pressure required to furnish the braking power is comparatively small.

To create a vacuum of seven and one-half pounds per inch in the collapsable cylinders and the connecting pipes of the train, requires the expulsion of one-half the air that fills them when the brake is off or at rest, and the *volume* of air *expelled* is, in round numbers,

three times as great as the volume of air compressed to forty-five pounds per inch, or three atmospheres and *one* cubic foot of air compressed to forty-five pounds flowing *into* the pipes and brake cylinders, does the work of *three* cubic feet of air flowing *out* of the cylinders and pipes of a vacuum brake. As quickness of action in a brake is of vital importance, it is then a matter of interest to know in which system the force will be transmitted the quickest through the pipes from end to end of the train, whether by *one* cubic foot of air compressed to forty-five pounds flowing *into* the pipes and cylinders of the train, or by *three* cubic feet at the atmospheric pressure flowing *out of* the pipes and cylinders in producing the vacuum, distance remaining the same in both cases.

Your Committee have been unable to get correct data as to the difference in *time* in the transmission of power by these two systems, other than that given by those forming an opinion from their own observation of the working of the two systems of brakes, and their testimony is that compressed air acts quickest in the transmission of power in the proportions given above.

The ingoing force of compressed air is a fixed and positive force, capable of being instantly applied, and can be graduated to any force desired on the brake shoes of the train, between nothing and the maximum, due to the pressure of air in the reservoir. Of the system of brakes operated by compressed air, that known as the Westinghouse Air Brake has so far met with favor from the greatest number of railroad managers; in fact, with the exception of the Loughridge Air Brake, and the Gardiner & Ransom, it is the only one in general use, and at the present time it is in use on about fifty-seven per cent. of the miles of railroad in operation in the United States and Canada.

The Westinghouse Brake is not considered perfect as yet, although it has been in general use for the past five or six years, the chief defect complained of being the valve motion to the steam cylinder and the length of time required to release the brake after coming to a stop, especially with a long train of cars. The latter is, doubtless, due somewhat to a want of a better system of springs for effecting the release than is used on the cars complained of, and the former to a want of better proportions and arrangement of the valve motion,

and intelligent attention on the part of the persons having charge of the brake. The want of a better or more reliable valve motion to the air pump has been the most serious objection urged against this brake, as reported to your Committee. Improvements have been made in the valve motion within the past two years, yet owing to its delicate proportions objections are urged, and a desire expressed for a more reliable valve arrangement than that heretofore used.

The distinguishing features of this brake are: the independent pump for compressing air, the automatic valves in the couplings between the cars, and the automatic "take-up" arrangement for taking up the lost motion, or "slack," in the levers and rods under the cars, keeping the brake shoes close to the wheels, and thus preventing loss of air in allowing a greater motion of piston in the cylinder than necessary, and the "triangular lever," by which a change of leverage is made to compensate for a decrease in the pressure of air incident to an application of the brakes and uniformity in all the various parts of the brake. One important feature claimed is the automatic valve in the couplings between the cars, which, in case the train should be severed, close the ends of the couplings so that the brake on the cars next the locomotive can be operated as well as before without any attention whatever, and in case the train should become severed after the brake is applied the brake will remain set on the detached part of the train. An instance of this kind occurred on the Louisville, Nashville & Great Southern Railroad, December 9, 1873, to a passenger train approaching a trestle, at a speed of twenty miles per hour, upon which an obstruction had been placed. The facts were furnished by Mr. Thomas Walsh, Master Mechanic of Memphis Branch, and are as follows: It being dark, the obstruction was not perceived until the locomotive was within sixty yards, when the brake was applied. The locomotive, tender, baggage car, and second class car were thrown down into the creek, a distance of twenty-five feet, taking the trestle down with them, but the remaining three cars, all full of passengers, *came to a stop, and with the brakes tightly set remained standing on the main track.* The forward pair of trucks alone were pulled off the track by the previous car as it went down before the coupling pin broke. We believe that this automatic arrangement by which the

pipes or hose are closed, in case the train is severed, either intentionally or otherwise, is not found in any of the other brakes referred to. With the Loughridge, Gardiner & Ransom, and Smith Vacuum Brakes, in case the train is severed while the brake is on, it is released from all the cars in the train, and can not be applied to any part of it until the hose, where parted, is in some way closed again.

Next to the Westinghouse Brake, the vacuum brake has, perhaps, come into use, so far as road and rolling stock is concerned. This system of brake, like all the others, has its defects. One is, that to a certain extent it lacks the *positive*, *certain unvariable* element of the compressed air brake, as the quickness of action and effectiveness depends upon the steam pressure in the boiler, and its power is liable to the same fluctuations. Mr. Loughridge in his answer to the American Railway Master Mechanics' Association Circular on the subject of brakes, in alluding to the vacuum brake, says in reference to the ejector: "The laws governing it are singular. The vacuum varies very much when the steam pressure in the boiler varies, and the nozzle is very uncertain in its action, something like the 'injector.' The force changes with the collapse of the sack or diaphragm, and the liability of the rubber to rot, or be cut by boys or discharged employees, and freeze in the winter, are objections." Of this brake Mr. Loughridge further states: "I canvassed this mode of applying the force, fully, up to 1870, and after a full and careful review of it, I preferred paying twenty thousand dollars for my patents of 1864 to enable me to use compressed air and produce better effects."

So far as the facts have yet been demonstrated, and from our experience and observation, and the opinions of others elicited in the foregoing investigation, your Committee are of the opinion that under all ordinary circumstances, and the conditions likely to arise in the use of a continuous train brake, compressed air supplied to a reservoir by an independent pump, and thus storing the power for applying the brakes whenever needed will give the best results, all things considered. The Westinghouse Air Brake seems to be, in the opinion of a majority of Master Mechanics, on the whole, nearer perfect than any other that has yet been brought into general use.

The above allusions to the Westinghouse Brake refer to the brake

as heretofore used. As the Westinghouse Improved Automatic Brake is being introduced on some of the leading railroad lines in this country and in Europe, and as there may be persons interested in this subject who are not familiar with its peculiarities, we consider a description of its distinguishing features wherein it differs from other brakes necessary. The air pump and main reservoir are situated on the locomotive, and are the same as used for the common Westinghouse Brake; the pipes and hose of the train and the brake cylinders are also the same; but under each car, near the brake cylinder and connected with it by a pipe, is an auxiliary reservoir from which the brake cylinder receives the air when the brake is applied. In the pipe between the auxiliary reservoir and the brake cylinder is an automatic triple valve, with an elastic diaphragm so-adjusted and arranged that when the air fills the pipes of the train it flows into the auxiliary cylinder through a small opening, filling it at the same pressure as that in the main reservoir and pipes of the train; but no air is admitted to the brake cylinders while the air pressure in the pipes of the train is greater or remains as great as that in the auxiliary reservoirs. To apply the brake it is only necessary to turn the three-way cock on the locomotive, cutting off the air from the main reservoir and allowing that in the pipes and hose of the train to escape, when the pressure of air from the auxiliary reservoir, acting upon the elastic diaphragm of the triple valve, lifts a valve admitting the air from the auxiliary reservoir on the car to the brake cylinder, and thus applying the brake; while to release the brake the air is again allowed to fill the hose and pipes of the train, which, acting upon the opposite side of the diaphragm the movement of the triple valve is reversed, cutting off communication between the brake cylinder and the auxiliary reservoir, and at the same time opening a relief or exhaust valve which allows the air in the brake cylinder to be exhausted direct into the open air, releasing the brake on the instant.

To graduate this brake so as to admit only a part of the full reservoir pressure to the brake cylinders, only a part of the air is allowed to escape from the pipes and hose of the train, the operation of the triple valve being such that the pressure admitted to the brake cylin-

ders corresponds with the difference between the air pressure in the hose and pipes of the train and that in the auxiliary reservoirs.

At some convenient point in the air pipe of each car is situated a valve of comparatively large area, so constructed that if raised from its seat it will so remain until all the air from the pipes and hose of the train has escaped. Attached to this valve, and extending down to within a few inches of the rails, is a trip rod, which, in case the car leaves the rails, or passes over an obstruction, this rod comes in contact with the track, ground, or any obstruction, the valve is raised from its seat, and the air from the pipes and hose of the train escapes, and the brakes of the whole train are applied on the instant, even while communication between the main reservoir and the pipes of the train exists through the three-way cock on the locomotive; the brake thus applying itself automatically.

For further and more accurate descriptions of the different parts of this brake, and for the results of a series of experiments made with a train equipped with it on the Pennsylvania Railroad, we refer to the April number of the *Journal of the Franklin Institute* for 1874.

The question arises whether the automatic brake referred to, with its delicate and somewhat complicated valve arrangement, will, on account of its merits, supersede the old Westinghouse Brake or similar air brakes. Will the advantages, in point of safety and reliability over the style of brakes referred to, be such as to warrant its adoption generally, and the cost of its maintenance in perfect working order?

Simplicity in the mechanical arrangements, as well as reliability and durability in a train brake is particularly desirable. The old or present Westinghouse Brake pertaining to the train is comparatively simple, and is, perhaps, as reliable as any that can be made with our present knowledge on this subject. Then the inquiry is made, in what particular is the automatic brake better or more reliable than the old brake? It will be remembered that the air pump and reservoir of both are the same, the only difference being in that part of it between the reservoir on the locomotive and the rear end of the train—a difference in the manner of applying its force.

In the old brake no air pressure in the pipes and hose occurs while the brake is *off*, such pressure only takes place while the brake is *on*

while in the improved or automatic brake the compressed air fills the pipes, hose, and auxiliary reservoirs under the cars, at the same pressure as in the main reservoir on the locomotive while the *brake is off*—the reverse of that which occurs in the old brake—and the automatic brake is applied by means of leaving the air *out* of the hose and pipes, the brake cylinders receiving the air stored in the auxiliary reservoirs on the cars, necessary for applying the requisite force to the wheels, and such force is graduated as desired by the relative difference in the pressure of air in the pipes of the train and that in the auxiliary reservoirs. To apply the brake with its full force all the air is allowed to escape from the pipes; if only a part of the force is required, only a part of the air is allowed to escape, reducing the pressure in the pipe to that requisite to bring the desired force on the brake shoes.

The old brake being applied and graduated by admitting the full or part of the pressure, while the automatic is applied by the reverse taking place, so far as the pipes and hose are concerned. The automatic brake has the disadvantage of a constant pressure inside of all the pipes and hose the entire length of the train at all times, except when the brake is *on*, thus rendering it more difficult to prevent leakage of the joints of the pipes and hose. Another objection urged is that it is liable to be applied by accident or designedly, when it should not be done, and which might be detrimental in its results. The bursting of a hose in any part of the train would apply the brakes with their full force, and they could not be released until such hose was removed and another one substituted and the air pressure re-stored again from the main reservoir, or except a cock was opened leaving the air out of each auxiliary cylinder in the train. These are some of the objections that may be urged against the automatic brake, aside from the additional care and attention requisite to keep the triple valve arrangement and other parts, not found in the old brake, in thorough and perfect working order.

The advantages of the automatic brake are, that in case the train is parted it applys itself on the instant to each car composing it—that attached to the locomotive as well as the detached part. Another is, that should a car leave the rails from any cause, the trip rods coming in contact with the ground or obstruction, the brake is

applied at once with its full force to the entire train. Another, and perhaps the most important advantage, is its *quickness* of action. Experiments have demonstrated that from one to two seconds only—depending upon the length of train—is required in applying it to the wheels with its maximum force. The force required being stored in the auxiliary reservoirs, close to the brake cylinders, and when the automatic valves open the brake is applied with the full force due to the pressure of air in the reservoirs. Quickness of action gives to this brake its chief value, and if it supersedes the old one, or other brakes, it will be largely due to that fact. Comparing the old brake with the improved automatic, it is probable that on a large majority of the passenger trains run on the roads in this country, the Westinghouse Brake as now in general use, will give, on the whole, better satisfaction than the improved automatic brake, on account of its simplicity, compared with the other. But there are fast trains run on many of the leading roads where, in our opinion, the automatic brake would be the means of insuring greater safety in certain cases:

1. In case a quick stop were necessary to avoid accident.

2. In case a car or any part of the train should be thrown from the track, or run over obstructions on the track.

3. Should the train part by accident the brake would instantly apply and bring both parts to a stop, avoiding danger from the rear portion colliding with that attached to the locomotive.

In such cases the automatic brake has the advantage, and in these respects is superior to the old brake.

But little information was elicited on the subject of driving-wheel brakes; comparatively few of them have been used up to the present time. With but one or two exceptions, those who have had experience with such brakes speak favorably of them. Brakes upon the driving wheels of passenger locomotives would, doubtless, give good results, and the time may not be far distant when such brakes will be applied to all locomotives hauling fast trains, for the reason that a retarding force equal to the propeling power of the locomotive can be utilized in that manner to bring the train to a stop, and there is no reason why a retarding force applied to the tires of the

driving wheels, should be more injurious in its effects on a locomotive than an equal propeling force applied to them from the cylinders, and we think that it will be less.

It will be shown in practice, we think, that good brakes applied to the driving wheels of the locomotive will very materially add to the efficiency of a train brake in making quick stops, being in effect the same as reversing the steam but without the injurious effect on the machinery of the locomotive that results from reversing while running. A train equipped with good brakes applied to all the wheels, except perhaps the engine truck wheels, can be brought to a stop in the shortest possible distance run, after the brake is applied, because to each wheel of the train is applied a retarding force about equal to that of the adhesion of the wheels on the rails, and when that point is reached nothing more in the way of a retarding force can be obtained from the use of a brake applied to the wheels. In making the ordinary stops of a train the driving wheel brake will be found to be advantageous, at least so far as a proper distribution of the retarding force applied to the train is concerned, as it gives to each wheel in contact with the rails its proportion of the retarding power necessary to bring the train to a stop. If a train equipped with a brake to the driving wheels, in addition to the train brake, at a speed of thirty miles per hour, is brought to a stop in a distance run of six hundred feet, it is evident that the train can not be brought to a stop within that distance when the driving wheel brake is not used, *all other conditions being equal.* In other words, if no retarding work is done by the driving wheels, *more must be done by the other wheels of the train in a given time* to effect the same result.

Brakes to the driving wheels of locomotives drawing freight trains have not heretofore been used to any considerable extent, and where their use involves the cost and maintenance of an independent or other style of air pump, it is not probable such brakes will be generally used, unless the brake can be applied to a part or all of the train also. There may be exceptional cases, however, where the advantages derived from the use of the brake on the driving wheels and tender only will compensate for the cost of the same, but further experience and investigation will be necessary before a correc

conclusion can be arrived at on this point. Under all ordinary circumstances the hand brakes on freight trains are sufficient in decending grades and for ordinary stops; and in order to avoid accident the locomotive can be reversed, and in that way exert a force equivalent to a brake on the drivers. Brakes upon the driving wheels of locomotives used for switching purposes are in use on some of the roads in the United States, and, so far as reported, give good results. It is not probable that the benefits to be derived would compensate for the cost of such brakes in a majority of cases, yet there may be others where the advantages will warrant the cost. The switching service is so varied that no rule could be suggested that would in the main be correct.

In some instances steam brakes have been applied to driving wheels of switching engines, and it is claimed with satisfactory results. The use of steam for applying the brake power direct to the wheels is not likely to meet with favor, however, on account of the constantly varying pressure on the pistons of the brake cylinders. The maximum pressure per inch is that of the boiler pressure, and varies with it; and it is found to be very difficult to graduate the pressure in the brake cylinders, from the fact that as soon as communication with the boiler is closed condensation in the cylinders rapidly reduces the pressure, and the moment it is again opened the pressure instantly increases to that of the boiler, so that a medium can not be reached that is not constantly varying, except through the intervention of a safety or other valve, which will admit of a certain pressure and no more, the surplus steam escaping.

Compressed air is in every respect to be preferred to steam for applying brakes to locomotives when it can be obtained at a reasonable cost. For instance: a locomotive fitted with an air pump and reservoir for a continuous train brake needs only a pipe connecting the driver-brake cylinders with the air pipe from the reservoir to the train, and they receive their supply of compressed air in the same way and at the same time that air is admitted to the other brake cylinders of the train, and in the same degree, all being controlled and graduated at the same time and alike.

To the twelfth question of our circular, all who answered it give it as their decided opinion that so far as the running of passenger

trains is concerned, a road can not be as safely and economically operated by the hand brakes as by the use of a good system of continuous train brakes under the control of the engineer, and that the benefits derived from the use of such a brake will more than compensate for the original cost and its maintenance thereafter, in preventing accidents and destruction of property, aside from its value as a means of greater safety and in time saved in making stops.

On this point there was no difference of opinion expressed, and it is safe to say that the day is near at hand when all passenger trains running at usual speeds and higher will be equipped with some good continuous train brake under control of the engineer, if not of others also on the train.

The question is often asked, "To what extent does a continuous train brake affect the wear of wheels as compared with the hand brake?" To this only a general reply can be made, on account of the changed conditions. With the hand brake quick stops, such as are made with the continuous brake, can not be made ordinarily, and while a part of the wheels of the train are exerting more than a proper share of retarding force, the others are exerting but little or none.

On the other hand the continuous brake, applied to all the wheels of the train, exerting upon each a comparatively slight retarding force, yet the sum of these forces make a large aggregate, and these retarding forces united bring the train to a stop without producing any injurious effect upon the wheels from a partial sliding on the rails, as frequently occurs in the case of the hand brake, and it is evident from this reasoning that the wear of the wheels is least with the continuous brake, *other conditions being equal.*

Perfection has not yet been attained in any system of continuous train brake, and we have purposely criticised the various styles of brakes now in use with a view of directing attention to their improvement where defective.

We consider the subject of continuous train brakes one of great importance to the railroad interests of this country, and a *perfect* brake, if such can be attained, will do much toward greater safety promptness, and economy in running trains. Continuous brakes of practical value are of comparatively recent origin, and the different

systems as yet have not been tested a sufficient length of time to demonstrate their comparative value, nor all the points in which they are defective.

Your Committee feel under obligations to Wm. Loughridge, Esq., for a drawing of his air pump and a description of the same, and for the facts set forth in his answer to the questions contained in the circular of your Committee.

Also to the Westinghouse Air Brake Company for data, drawings, and other valuable information furnished us. We trust we have been able, in some degree at least, to embody in this report the facts furnished us by these and all other parties on this subject.

Respectfully submitted,

R. WELLS, *J. M. & I. R. R.*,
E. B. GIBBS, *L. C. & L. R. R.*
L. H. WAUGH, *K. P. R. R.*, } *Committee.*

On motion, the report was accepted.

THE PRESIDENT—The subject is now open for discussion.

Mr. PEDDLE, St. Louis, Vandalia & Terre Haute Railroad—Mr. President, the Committee in their report quote Mr. Loughridge on the Smith Brake, but say nothing of the Westinghouse Air Brake. If Mr. Loughridge has anything to say about that in his reply to the question submitted, I should like to know.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—I believe that he only alluded to it in a general way. I do not remember that there was anything about that one in particular. He alluded to that, with other systems of brakes, in comparison with his own; but I do not think he specified the Westinghouse Brake in particular. He alluded to the vacuum brake, and objected to it; but I think he was mistaken in his objection. That is my recollection in regard to the Westinghouse Brake.

Mr. PEDDLE, St. Louis, Vandalia & Terre Haute Railroad—I merely asked, because I supposed he would also have something to say about the Westinghouse Brake. I thought he would be prepared to give both sides of the question. There is another thing I would like to ask the Chairman of the Committee. He speaks about the Smith Brake as compared with the Westinghouse Brake being as nine to sixty in the application of the power; I do not exactly understand, but I would like to be better posted in regard to it.

Mr. WELLS, Jefferson, Madison & Indianapolis Railroad—I do not know as I can explain that very clearly. In obtaining a vacuum you have, as it might be expressed, a head of nine, or the difference between nothing and nine; but in admitting air at a pressure of sixty pounds you have got a head

or force of sixty pounds to drive it in, and in that vacuum brake you have only a head of nine pounds to get it out.

Mr. PEDDLE, St. Louis, Vandalia & Terre Haute Railroad—We have that nine pounds in the vacuum brake on the surface, and you have a pressure of forty pounds, not sixty pounds, to the inch, exerted on a portion of the small surface, while we have nine upon the large surface.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—You do not understand me. I only alluded to the force or power in getting the air out and getting the air into the cylinders, not to the effective force of the cylinder at all. Of course it is the same in the cylinder having nine pounds pressure to the square inch as in another having sixty pounds to the square inch, if you make a difference in the size. Where you have but nine pounds to the inch you increase the size to the point desired to get the power required. The reference in the report to the difference between nine and sixty is in the head or force to create a vacuum and to put the pressure in the cylinder.

Mr. PEDDLE, St. Louis, Vandalia & Terre Haute Railroad—At the application?

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—At the application. It has nothing to do with the power applied by either one to the brake.

Mr. PEDDLE, St. Louis, Vandalia & Terre Haute Railroad—There is one more thing I wish to inquire about, but I do not want to criticise the report of the Committee, for I think very highly of it, but I think they ought to have given us some idea of the expense of the Westinghouse Brake, as that is a very important feature of the question. There was nothing said about that. We have all the advantages set forth, but I think we ought to have the disadvantages as well. Now, on the Smith Brake I understand the running expenses are very light. I do not know what the first cost is, but I believe it is somewhere near the Westinghouse Brake, but the repairs are very light, as I understand it. But the Westinghouse Brake is, as we all know, a very expensive institution, and requires an expert in the business to keep it up.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—In reference to the expensiveness of the brake I do not think that that would figure very largely in the matter if there was any difference in the effectiveness of the brake. These brakes are used on trains having passengers, and the question is, which is the best brake of the lot? Which is the safest, so far as the traveling public is concerned? That is a matter of much more importance than merely a few dollars in the first cost of the brake, or in the cost of keeping it up. The prevention of one accident a year on a passenger train would pay for all the brakes you have on the road, and for keeping them up, too, so that the matter of difference in the first cost is a secondary consideration.

The brake that is the most effective is the cheapest, even if it costs the most at first. Now, your Committee used all the means at their command to get information on these points, but we did not direct our attention particularly to ascertaining what the difference was in the cost. We confined it more particularly to the qualities of the brakes themselves, as we considered that a matter of more importance than the cost. Now, I hope that all the members in this Association will have something to say in regard to this question, and that they will criticise the report just as much as they please. I am always glad to hear both sides of the story, and in making up this report I will state that I was governed by my own judgment and by the light I had at my command, and I had very little assistance from any other source. All that I got I had to go out and hunt up. As was stated here to day in regard to the replies of the Master Mechanics to the different circulars, they were, to a very great extent, "Yes," and "No." That was about all the information we could get, with a few exceptions. There were about half a dozen persons who replied at some length on this question, but the balance of them were but little more than yes and no.

Mr. PEDDLE, St. Louis, Vandalia & Terre Haute Railroad—Mr. President, I do not think anybody who knows Mr. Wells will impugn his motives in the least. I do nothing of the kind, far from it.

Mr. HUDSON, Rogers Locomotive Works—Mr. President, it appears to me, supposing the power of the two brakes to be as nine to sixty, that that hardly represents their relative value, because, if I understand it, if those forces were respectively available in the same time, then they would be equally valuable; but the force of sixty pounds is available instantaneously, while it takes some little time to get the force of nine pounds. You have got to exhaust the air; it begins at nothing and gradually goes up to nine pounds; while you are doing that your train may be going over the bank or somewhere else!

Mr. EDDY, Boston & Albany Railroad—Mr. President, I do not feel myself competent to discuss what, perhaps, should be the merits of these two brakes, but as I have had some little chance to witness their operation upon other roads as well as our own, perhaps I may throw out an idea or two, and give some information which may be of a little service in drawing out something else from some other person, if nothing more. It may not be known to but few of the Master Mechanics present that on the Boston & Maine Railroad they instituted a series of experiments for the purpose of trying the Westinghouse and the Smith Vacuum Brakes. It so happened that I was present, but I took no minutes of the experiment. The result, however, was like this: These trains, bear in mind, were running beside each other precisely at the same rate of speed, and at a given signal the brakes were applied simultaneously on both trains. At the commencement the Westinghouse Brake, having a storage of compressed air, seemed to

take hold, and did take hold a little quicker, but the vacuum brake took hold very quick, and more gradually and easier on the train. In the several experiments there was some little difference in them; but as near as I can recollect there was but very little in the checking up of the train. The Smith Brake would keep increasing in its power, while the Westinghouse Brake decreased. Allusion was made in the report of the Committee to mischievous persons who might cut a hole in the diaphragm of the Smith Brake. I am happy to inform you that that thing has since been done. I proposed to try the effect and see what the result would be. The result that you get by cutting a hole in there when you apply the brake is, that the atmosphere outside closes up the hole, and the brake will operate just as well. If you cut out a piece of course it is gone, but it is not entirely gone then, because it has been demonstrated that you can go to the rear end of the train pipe and let it wide open and put the brake on almost as effectively as with it closed. The power of the ejector is so much, exerts such a force, and flies so quickly, that with the pipe open at the rear end of the car the brake is effective even then. We have on our road about an equal number of the Smith and Westinghouse Brakes, and if the opinions of the men who operate these brakes and run them, are worth anything, they would be very happy to swap the Westinghouse for the Smith. I took considerable pains, and was instructed by the officers of our road, to ascertain before we put the Smith Brake on our road all that I could in relation to it. I went to the Boston & Lowell Railroad; I did not go to the officers merely, but I went to the engineers, and to one in particular who had run it the longest—he had run it considerably over a year at the time I made inquiries of him, and he said it had never cost a single cent for repairs in any way, shape, or form, except what he had done himself in packing the throttle. It never had failed, and he made about one hundred stops a day. He was running the accommodation train between Boston and Lowell which made about that number of stops. I have my doubts, Mr. President, whether a parallel case to that can be brought up for the Westinghouse Brake; certainly it can not on our road, although it is a comparison I am now drawing between the two. The Westinghouse Brake is a good, efficient brake, but as far as my experience and knowledge goes, it is not as sure every time as the Smith Brake. We have come just as near as we could, to not have it, of having two or three accidents on our road at crossings of railroads and at curves, in consequence of the failure of the Westinghouse Brake.

Mr. Robinson, Great Western Railroad—I would like to ask Mr. Eddy what the cause of the failure, or the one or two failures, of the Westinghouse Brake on his road was?

Mr. Eddy, Boston & Albany Railroad—The pump refused to work; that is all I can tell you.

Mr. Jackman, Chicago, Alton, & St. Louis Railroad—Mr. President, I **hould a** great deal rather hear from some of the others here in regard to **his brake** than to say anything myself, because I think I have not had as **nuch experience** as a good many of them have had with the Westinghouse **brake, and** I have had no experience with the vacuum brake. I have used, **owever,** the steam brake for about two years. I have tried it very success-**ally; and** our trial with the steam brake has convinced me, as well as all **ne others** connected with the road, that the steam brake is not the thing—**hat is,** I would not recommend its adoption by any road. The brake we **re using** now is the Westinghouse Automatic Brake Attachment. I will **e as brief** as possible, but I will allude to one particular point, so far as that **s concerned,** and leave it, because in the report of the Committee it is very **laborately** treated. They say that they have not received much definite in-**ormation** with regard to its use on the drive wheels. We have six locomo-**ives** now that are equipped with drive-wheel brakes, beside a good many **nore** with the brake without the drive-wheel brake. I followed this rule, **and** thought I would try it until we had used it enough, so that I could dis-**cover** whether it would be of any use or not. So far as we have used it, on **the drive** wheel, its results have been very fine indeed; and I have not seen **a single** thing that would lead me to speak unfavorably of its use in this man-**ner,** and it certainly is a great help in stopping the engine and in stopping **the train,** and the engineers who run the six engines, and those who have **seen** the operation of it thus far on the six engines, desire to have the appli-**cation** of the brake to the drive wheels as well as to the tender. That shows **that** as yet they have not found a single thing that they could say against it, **that** is as far as my experience goes with regard to its use on the drive **wheel.** So far as the effect of the automatic brake is concerned, there are **some** questions which have been brought up in this report that we have got **to** answer by experiment, and that we shall find out in our own practice, as, **for** instance, whether there is any difficulty that will come, such as has been **spoken** of. Thus far, to the extent that we have used the automatic brake, it has given us very good satisfaction, and we have made some of the most excellent stops with it. I have seen the train running at a pretty high speed brought up much quicker than I had any idea a train could be stopped with a brake. It worked very fine. I desire to hear from some of these persons who have had a good deal more experience with this brake than I have.

Mr. Eddy, Boston & Albany Railroad—Mr. President, the Connecticut River Railroad, so-called, I believe are putting it on all their freight engines, and think more of the brake for their freight trains than they do for the passenger trains. I think we have put the vacuum brake on some three or four, but I believe they are putting it on all their engines. I do not know that it makes any difference which we use.

Mr. Jackman, Chicago, Alton & St. Louis Railroad—Mr. President, I

would like to make an inquiry as to how much steam it requires to operate the vacuum brake—that is, what the wastage of the steam in the application of it is.

Mr. EDDY, Boston & Albany Railroad—I think that we could answer that question in about the time we answer the question how much it takes to drive the Westinghouse pump. Let me tell you one thing which is different with the Smith Brake from what it is with the Westinghouse. We use, as a matter of course, the steam for the vacuum brake when we do not want it for any other purpose, and when you shut off your steam, to run into the station, especially with coal, oftentimes it flashes up and you are glad to get rid of it; while, on the other hand, you have got to make your steam on purpose for that use.

Mr. JACKMAN, Chicago, Alton, & St. Louis Railroad—The reason I asked the question was I had been informed that with the application of the brake you lower the steam in the boiler to the amount of ten or fifteen pounds directly, and some have put it even larger than that. If such be the fact it is readily told about what amount of steam is taken from the boiler by the application of the brakes where you have to make stops. It takes considerable time to do that. I never have seen the operation of it, consequently know nothing only what others have told me.

Mr. EDDY, Boston & Albany Railroad—I suppose you are all aware of the manner in which that acts, and the way it is fitted up. You open your cock and form your vacuum which takes but an instant; it need be opened but an instant; then your valve closes and holds it there, and if you can lower your steam in the boiler ten or fifteen pounds in that way it is news to me.

Mr. HAYES, Illinois Central Railroad—Mr. President, Mr. Eddy and myself were appointed a committee during the Convention at Boston to witness the action of that brake, and in answer to Mr. Jackman I would say that I watched the indicator on the engine very closely, but I could not see any movement of the hand at all when the brake was applied, but I did notice this one particular, it took about fifteen seconds to create the power. In the Westinghouse Brake you had that already created, reserved in the tube; and I observed to Mr. Smith that I thought if he could arrange his vacuum to have a tank, and operate the brake, he could create it at once, so that he could apply it immediately, and it would be equal to the other. I have, however, this opinion of the two brakes, that the Smith Brake, or the vacuum brake, would take less force from the engine for the power created than the Westinghouse Brake. But it certainly does take about fifteen seconds to create the power that you need.

Mr. EDDY, Boston & Albany Railroad—Mr. President, I am not disposed to criticise what Mr. Hayes has said. What he says is true, or was true then, to a certain extent; but I think, if I am not mistaken, that was about the first brake that was put on. It was put on in a great hurry, and everything was, as it is apt to be in all new inventions, very incomplete at the time. If

Mr. Hayes will take the trouble to see the operation of it now he will find out the difference.

Mr. HODGMAN, Philadelphia, Wilmington & Baltimore Railroad—Mr. President, I do not care to take up the time of this Convention in the discussion of this question of brakes, but as we have about an equal number of each kind, I thought I would just try to help Mr. Eddy out. He seems to be all alone in trying to sustain the vacuum brake. I would suggest in reply to Mr. Jackman, that in applying that brake it lowers steam generally about one pound or two by the gauge, and we use that steam at a time when we do not have any other use for it. The Westinghouse Brake is using steam all the time the whole length of the road, and of course it must use more or less fuel. In regard to repairs, let me say a few words. We have, I think, about fifteen of each kind of brakes—I am speaking now of engines, I know nothing about the car repairs—the Westinghouse Brake averages from ten to fifteen dollars per month, and the vacuum brake has not cost us a dollar a month for repairs. To corroborate one statement that Mr. Eddy made in regard to the opinion of the engineers on the brake, so far as I know they are all very glad to change from the Westinghouse to the vacuum. I would state that the vacuum brake has given very good satisfaction on our road, especially on the way trains. We run it altogether on the way trains, and the other brake on the through trains. The reason that they like them on the way trains so well is because they let up so quick, and allow them to get away from the station so readily. Our engineers, using them between Philadelphia and Wilmington, where they make from eighteen to twenty stops, can make from six to eight minutes better time with the vacuum brake than they can with the Westinghouse, therefore I think as to time it is an advantage as well as to expense for fuel and repairs. I suppose every Master Mechanic in the country is working, or ought to be, to reduce the expenses of his road, and if we can avoid complication in machinery we take a step in the right direction by adopting the simplest, and the vacuum is the simplest brake that I have ever had anything to do with.

Mr. LILLY, of Indianapolis—Will the gentleman state how the two compare in distance or stoppage?

Mr. HODGMAN, Philadelphia, Wilmington & Baltimore Railroad—We never have tried them side by side. The only time I ever saw them tried was that which Mr. Eddy speaks of on the Boston & Maine Railroad. I think there, without the automatic brake, they were the same, but with the automatic attachment to the Westinghouse Brake they differed a little. Perhaps there is some one here who can give the exact time.

Mr. EDDY, Boston & Albany Railroad—It has been said, and it may be said again, that the vacuum brake does not operate on our long trains, but that it will do tolerably well with a short train. In reply to that I have to

say that in this trial there were thirteen long cars, and as far as I was capable of judging it worked equally well, if not better, on the long trains than it did on the short ones.

Mr. Wells, Jeffersonville, Madison & Indianapolis Railroad—Mr. President, I would like to ask Mr. Eddy, or some gentleman who was present at that trial at Boston, whether the two trains referred to—the one having the Westinghouse Brake, and the one having the vacuum brake—were under the management of a committee appointed to ascertain the difference, if there was any, in the time that it would require to make the stop with the two brakes.

Mr. Eddy, Boston & Albany Railroad—I think they had two experiments at different times. If I am not mistaken, the first one was gotten up at the suggestion of Mr. Sellers (Westinghouse Brake), and that the advocates of Mr. Smith, and those in favor of the vacuum brake, were not present at that time. But when the Smith Brake was operated, I do not know but Mr. Smith was there. I think, however, he had nothing to do with the experiment. The second trial was gotten up, I think, by the managers of the road; but I do not know. I know that Mr. Smith and Mr. Sellers were there, and that there was a committee appointed to conduct the experiment; but under whose control it was I am unable to say. My impression is that the experiments were entirely under the control of the Committee. They were very elaborately gotten up for that purpose. There were, I should think, from six to ten stops made.

Mr. Sellers, of Pittsburg—Mr. President, Mr. Lauder is present, and I should like to hear from him, as he was present at the trial in Boston.

Mr. Lauder, Northern New Hampshire Railroad—Mr. President, I did not propose to say anything on the subject of brakes, as I think it is inclined to be discussed here as much as it will bear; but inasmuch as I have been called upon, I suppose it will be proper for me to make some remarks. I was present at the trial on the Boston & Maine Railroad with the two brakes; in fact, I was one of the Committee to conduct the experiments. There was a strong effort made to have the experiments conducted in a certain way at first; but the Committee refused to act unless they could have something to say about it. It was finally referred to them to make such experiments as they saw fit. In the first place, then, we made three stops with the two trains furnished by the Boston & Maine Railroad. I think there were twelve cars in each train, and they were as nearly alike as possible. The stops were made by a signal given, passing over some torpedoes. In what condition the trains were, I am not able to state further than this, that I know there were some cars equipped with the Westinghouse Brake that were in such a condition that, when the brake was put on, the piston would go against the cylinder. How the vacuum brake was, I am not able to state; but I presume it was in good condition. There were three stops made, two of which the

vacuum stopped the train about thirty feet distance, if I remember rightly, shorter than the Westinghouse. In the other trial the Westinghouse beat the vacuum.

Mr. SELLERS, of Pittsburg—I would like to ask Mr. Lauder if the Westinghouse Brake Company furnished the brakes for that train.

Mr. LAUDER, Northern New Hampshire Railroad—They did not; the roads furnished the train, as I understand it. I have heard that the Westinghouse Company had formal notice of the trial, and that they were invited immediately before the trial. There was a train provided by the Westinghouse Company to make trials with on the Eastern Railroad, but when we got out to Danbury, I think it was, we found the train there. After making these trials with the two Boston & Maine trains, we then took in this train with the Eastern Railroad, a train of eight cars, I think. We took off eight cars having the vacuum brake and made some experiments with them. That train was equipped with the automatic attachment—the auxiliary attachment to the Westinghouse. There were three stops made, I think, with those trains. I do not remember about the last two, but I know about the first. When they stopped then the vacuum train was five cars and the engine ahead of the Westinghouse train. That stop was made with the automatic Westinghouse. Then as regards releasing, on our road we have both brakes. We have got our through train equipped with the Westinghouse Brake, and we have got one local train equipped with the vacuum brake. I am prepared to say that in my opinion both brakes are good and work well, but I certainly must give my preference to the Westinghouse Brake. I think it is more reliable—at least I have always found it so. In the matter of repairs I do not know how a brake can be made to cost fifteen dollars a month. I do not think we spent five dollars a year to keep our pumps good. It is certainly safe to say we did not expend that amount in their repairs. I have my own opinion in regard to that Boston trial. My impression is that the cars equipped with the Westinghouse Brakes, on the train furnished by the Boston & Maine Railroad, were in very bad condition. Whether they were in any worse condition than the vacuum I am not able to say. I might say in regard to the brake releasing just a few words. There are roads that have heavier trains than we had. We run from five to nine cars equipped with the brake, and I never saw any trouble about its releasing in these experiments. Although I was not present, I think in going up from Boston they tried an experiment of the time occupied in the stopping and starting. If I recollect rightly the Westinghouse train had the advantage in the matter, but I presume, though I am not sure, that they had the automatic brake. The report in the papers gave the Westinghouse Brake the advantage.

Mr. EDDY, Boston & Albany Railroad—The gentleman does remember rightly. The Westinghouse Brake did have the advantage going back. I can tell you how it happened, for I happen to know. The engineer on the

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engine that had the vacuum brake through some mismanagement let his steam go down, and he had but little steam. So much for that. Now then, in discussing the vacuum brake in connection with the Westinghouse, I do not put it in comparison with the automatic brake, because my opinion is that that is so complicated that no road will ever attempt to use it with the automatic attachment. The stops were very much in favor of the Westinghouse Brake.

Mr. JEFFREY, Illinois Central Railroad—Mr. President, I have just been consulting with Mr. Hayes and the Master Mechanic of the Southern Division of our road, and the Master Mechanic who has charge of the shops here in Chicago, and they inform me that during the last year they ascertained the average cost per month for labor per engine for the Westinghouse Brake was some seventeen hours for the year 1873. Taking that at thirty cents an hour, you make the average five dollars and ten cents per month for repairs on the Westinghouse Brake. The gentlemen can add to that the material and form as good an estimate as I can as to the average cost. The probabilities are that it will range from six to seven dollars per month. We have in use on the road forty-eight Westinghouse Brakes on engines, and a separate account is kept of the labor and material used, so that we can form a definite idea in regard to the cost of repairs. Of the real merits of the two brakes I can say but little. I have seen plans of the vacuum brake and that is the substance of what I know in regard to it. Judging from the plans it looks like a good, simple brake, and as a mechanic I see no reason why the brake would not perform its duty well. There is but little machinery about it. It is a pressure of nine pounds to the square inch, and a suitable-sized diaphragm under the car, I see no reason why the brake can not be set up as well as it can with the Westinghouse arrangement; but we use the Westinghouse Brake and it has given great satisfaction on every division of the road, both the prairie and heavy-graded sections. In going down the heavy grades it enables the engineer to graduate the speed at will.

Mr. EDDY, Boston & Albany Railroad—I do not wish the gentlemen to understand, in the discussion of this matter, that I have any feeling either one way or the other—either for the parties for the Westinghouse Brake or for the other. All that I have to say, Mr. President, and all that I have said, is simply in the interests of fair play. Now, then, when a man says the Westinghouse Air Brake doest not cost, to keep it in repair, more than the gentleman who last spoke says, I want to know how it is done. I would like to ask the gentleman whether all the repairs put upon its pumps are done by the men in the shop, or whether his engineers do it? My engineers that run those brakes tell me they would rather keep all the rest of the work in repair than to keep them in order. Whether we are different from all other companies, or whether we get bad pumps, or whether we get poor mechanics, I do not know; or what the matter may be, I am not prepared to say.

Mr. FELLOWS, Lake Shore & Tuscarawas Valley Railroad—Mr. President, I would like to ask Mr. Eddy if he can give us any information in regard to the cost of repairs in the brake arrangement under the cars having the vacuum brake. Is there anything to become disarranged that would be likely to make a bill of expense?

Mr. EDDY, Boston & Albany Railroad—Mr. President, I can not do that; the cars do not come directly under my supervision; but I am informed by those who ought to know, that if we leave our engines to stand in the house a few days, having the Westinghouse pump on, it is very likely not to work when it is called upon to do so; and the cylinders of the brakes, if it stands a few days, want looking to, fixing up, cleaning, oiling, and are very unlikely to work. This I can not say of my own knowledge, but it is easy enough to see that the sacks of the Smith Brake have none of those things to contend with. I know that the sacks that were put on the Boston & Lowell Railroad at the time of the trial that Mr. Hayes speaks of, were all there fifteen months afterward, and never cost a cent for repairs.

Mr. FELLOWS, Lake Shore & Tuscarawas Valley Railroad—Mr. President, the reason I asked that question is because the repairs of the cars on our road, as well as the locomotive, come under my jurisdiction. I can safely say that the repairs of the brake, arranged under the car, would cost us more than the pump repairs on the engine. We have the automatic arrangement for taking up lost motion on the brake, and it don't work worth a cent, nor have we ever been able to make it work, although we took the pains to write to Mr. Westinghouse and get his full directions about putting them on. We made an entire change under three of our passenger coaches, and are doing so under the others as rapidly as we can, for the purpose of conforming to his directions, and still they will not work. It is unsatisfactory, so much so, that the brakemen are now compelled to take the slack up by the wheel at the rear end of the cars in order to make them work. Then the manner of letting off the Westinghouse Air Brake on the long train is certainly not satisfactory, although they have the air cock in the couplings between the cars. I will state a little circumstance that happened upon the Lake Shore Railroad, and in doing so, Mr. Sedgley will correct me if I am in error. Not long ago their train, No. 5, came to Elyria and stopped at the junction with a heavy train on a heavy grade. In starting, the brakes did not let off, and the engineer could not start his train. By some means, I do not know how, the throttle became disarranged and he could not shut it off, and his engine stood there and slipped until it caused a deflection in the rail of nearly half an inch where the four drivers stood. I have seen the same thing occur several times, in fact it is of almost daily occurrence at that point with those heavy trains of from eleven to thirteen cars. It is a pretty difficult matter to get such trains away from there, and very often you will hear the engineer call to let off brakes, which, I suppose, means calling the attention of

the brakemen to these air cocks in order to make use of the air. Now, if the vaccuum brake has no arrangement that is likely to get out of order in that way, and cause its repairing, there is an advantage; if they will let off on long trains there is a decided advantage. By the arrangement of the Gardener & Ransom Brake, as they claim in their patent, they can let the brake off just as quickly and as effectively as they can put it on. They have the four-way cock. That is what they claim as an improvement. Their pump for pumping air, I think, is more substantially made than the Westinghouse pump. I have seen some of them work, both as experiment, where they were put up for testing, and also on engines where they had been put on for service. They have one on the Cleveland & Columbus Railroad that I saw very often; but only a few days ago I was talking with the engineer in regard to it, and he says that that pump has never cost any labor more than to do the packing, and is always ready to work, no matter to what point the pressure in the boiler falls, unless you shut off steam from the pump, when it will stop working; but it does not matter in what position the pump is when the steam is shut off, or when it is put on, the pump goes to work just as readily. That is not the case with the Westinghouse pumps at all times, although they have improved their pumps to such an extent that we have trains that never delay us if the pumps are properly packed. But the repairs on these pumps is quite an item. We have broken several parts in using them, because they are lightly constructed in many of their parts, and it necessarily must be so from the size of them. But when they have broken the Westinghouse Company have replaced the parts without any charge, so far, upom simply remitting to them the old parts that were broken. If we had been to the expense of buying those parts the expense of our repairs would have been very materially increased and been a considerable item; as it is I do not know that I can say the expenses of repairing has been so very great, but I think they will run over five dollars a month. Now, if the Gardener & Ransom pump will relieve the brake from the wheel as readily as it can be put on, as they claim it will, and if it can be put on as effectively as the Westinghouse, then there is a decided improvement. If their pump in its working is accurate every time, and without trouble, there is another improvement. If they have built it more substantially, as I believe they have—for it is certainly simpler in its working—there is still another improvement. If the vacuum brake will do the same thing without the complication of machinery under the cars, there is most certainly an improvement in that.

Mr. Wells, Jeffersonville, Madison, & Indianapolis Railroad—Mr. President, I would like to have it explained to me why it is that the vacuum brake will release itself better than the Westinghouse, and why the Gardener & Ransom Brake will release itself better than the Westinghouse? If it does it is on account of some defect in the arrangement of the brake springs, or

something like that, because the only way that the Westinghouse Brake is released, or the Gardener & Ransom Brake, is by allowing the air to escape outward. If the air escapes outward at all, as there is no pressure in there, it escapes in the manner just as it does in the other. But in the vacuum brake it is released by allowing the air to flow inward and fill the space again. Now, how can there be any difference between the air coming in to release the brake and coming out to release the brake? So far as the principle is concerned there can be no difference. The one may do it just as well as the other, provided they are adjusted properly. Now, Mr. President, the main point in this brake question, to my mind, is, what system of brakes can be applied the quickest? And that is where the whole matter of difference rests really. If the present air brake can be applied with its mechanical force as well in a shorter space of time than the vacuum brake, as a matter of course it must, to that extent, be better. If the vacuum can be applied as quick as the other, then, as far as that is concerned, it is equally good in its operation. There may be some things in which one is more valuable than another; but this matter of time is one of the most vital and important elements in the brakes. So far as the cost of keeping up the brake under the car is concerned, it seems to me the cost of keeping up the vacuum brake would equal that of the Westinghouse or any other simple arrangement, from the very fact that there is substance used that will deteriorate after a while. The rubber diaphragm will, in course of time, have to be renewed. In fact I have had considerable experience in keeping up the brakes on the cars on our line, and I have found that the Westinghouse arrangement has made scarcely any trouble in keeping it up. In regard to this arrangement for taking up the lost motion in the brake, I will say that, although I have not put very many of them on, those that I have put on have, so far, worked perfectly. I have had no difficulty with them at all; neither have I experienced any trouble in releasing that brake—not a particle. If that brake is properly put on, with proper springs, and properly adjusted, it will release itself just as quick by allowing the air to flow out as the vacuum brake will release itself by allowing the air to flow in.

Mr. EDDY, Boston & Albany Railroad—Mr. President, I have already consumed more time than I had intended, and I beg to apologize for doing so, but the gentleman asks one question, and I am a little surprised that he should ask it. He wishes to know why the Westinghouse Brake will not release itself as quickly and freely as the Smith Brake. It seems to me to be so apparent to everybody that I am surprised that he should ask such a question as that. The Westinghouse Brake has a cylinder and piston in it, and that piston has got to be tight enough to prevent the air from passing by it, and consequently it must have some friction. Now, that question is equivalent to asking why the piston that is made air tight, will not work

just as readily in the cylinder as a rubber bag will expand when you take the air away from it.

Mr. FELLOWS, Lake Shore & Tuscarawas Valley Railroad—Mr. Eddy has answered only a portion of the question, and if you will allow me the privilege, Mr. President, I will answer the other in the best way I know how. The principle of the Gardener & Ransom Brake in releasing, as I have said before, is by a four-way cock. The Westinghouse has a three-way cock also, and one office of it is to exhaust the air from the cylinder when you do not want to use it. One of the claims of the Gardener & Ransom Brake to superiority is that by the use of the three-way cock, after applying the brake, they can turn that quickly and apply the same pressure from the cylinder into the cylinder under the car to release the brake, that they used to put it on, and it is just as instantaneous. I do not care how long the train is, it is just as effective, as it will apply the brake as well and as surely, and let it off as quickly, as it is applied the same as on the short trains, and it is done by the same pressure that puts it on by admitting it into the other end of the cylinder under the car.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—Mr. President, I will only say to the gentlemen who are so familiar with all these brakes, that had they furnished your Committee with the information at their hand, we perhaps might have avoided some mistakes that we have made. In regard to Mr. Eddy's question I will state that on the brakes I have had charge of the springs are sufficiently strong to overcome the friction of the piston sliding in the cylinder, so that all there is to do is to let the air flow out, and the springs throw the piston back, and the brake releases itself as easily as the air flows in with the other brake, as that releases itself.

Mr. EDDY, Boston & Albany Railroad—Mr. President, just one word. I do not know but the gentleman can adjust a spring there that will take that piston back every time as soon as the air is let out, but it seems to me if he does that oftentimes he will have a great deal more power than is necessary, for all that know anything about it know the piston heads stick a great deal more sometimes than they do others.

Mr. FORNEY, Railroad Gazette—Mr. President, I move that this discussion be closed.

Carried.

Mr. PEDDLE, St. Louis, Vandalia, & Terre Haute Railroad—Mr. President, I have a resolution I would like to offer.

Resolved, That the thanks of this Association are due to its Secretary, Mr. Setchel, for the able personal attention which he has given to the requirements of his office during the past year, and that the sum of $500 be paid to Mr. Setchel as an acknowledgment of the same.

On motion of Mr. Hayes the resolution was adopted.

Mr. Robinson, Great Western Railroad—Mr. President, in the report of the Mechanical Laboratory Committee it was mentioned that Messrs. Prosser & Son, of New York, had kindly donated a dynamometer to this Association. That dynamometer is now at the other end of the room in a box, and can be examined by whoever may wish to do so. In connection with that dynamometer I beg to offer the following resolution:

Resolved, That the thanks of this Association be conveyed to Messrs. Prosser & Son, of New York, for their donation to our Mechanical Laboratory.

Resolution adopted.

Mr. Setchel, Little Miami Railroad—While resolutions seem to be in order I desire to call the attention of the Association to a fact I forgot to mention in my report, that the Association, during the past year, has been the recipient of a donation from the Rogers Locomotive Works of fifty dollars, and from W. W. Evans, of New York, of five dollars. I would move that a vote of thanks be returned to each donor for their contributions.

Carried.

Mr. Setchel, Little Miami Railroad—Mr. President, I have another resolution:

Whereas, An All-wise Providence has removed from our midst by death our friend and brother-member, J. R. Gayle, be it

Resolved, That we tender to the bereaved family our heartfelt sympathy, and mourn with them the loss we deeply feel, but can not repair.

Resolved, That the Secretary be instructed to transmit a copy of these resolutions to Mrs. Gayle, and also publish the same in our Annual Report.

Resolution adopted.

Mr. Robinson, Great Western Railroad—Mr. President, I would like to ask the Convention what shall be done with that dynamometer?

Mr. Eddy, Boston & Albany Railroad—Mr. President, this thing is all new to me, but it seems to me that that instrument was given with the understanding that we were to have a laboratory. Inasmuch as we have not got one, and have no place to put it, it seems to me that the instrument, with our thanks, ought to be returned to the donor, to do what he sees fit with it until such time as we may have some place in which to keep it. I can not see any other disposition to make of it. I simply throw out the suggestion.

Mr. Hayes, Illinois Central Railroad—Mr. President, I would move that it remain in the hands of the Supervisory Committee, they to dispose of it as they see proper.

Motion carried.

The President—I will call now for the report of the Committee on Place of Meeting.

The Secretary read the report of the Committee on selecting a place for holding the next annual meeting.

Report of the Committee on Place of Meeting.

GENTLEMEN: Your Committee, appointed to select a place for holding the next annual meeting of the Association, beg to report the following cities. The first mentioned, however, would appear to meet with the most favor, and your Committee therefore recommend it: New York, Cincinnati, and Montreal.

Respectfully submitted,

EDWIN GARFIELD, *H., P. & F. R. R.*,
R. WELLS, *J. M. & I. R. R.*,
W. A. ROBINSON, *G. W. R. R.* } *Committee.*

On motion of Mr. Elliot the report was received.

THE PRESIDENT—The Constitution says that the regular meeting shall be held at such place as may be determined by the majority of the members present at the previous meeting. The majority of members present will decide where the next meeting will be held.

Mr. SPRAGUE, of Pittsburg—Mr. President, I would like to mention another city besides those mentioned by the Committee, if it is not too late.

THE PRESIDENT—It will be in order to suggest any other places not mentioned by the Committee.

Mr. SPRAGUE, of Pittsburg—It is the city of St. Louis; we talked of going to last year but deferred it one year on account of the St. Louis bridge not being completed. I move that St. Louis be added to the list.

Carried.

On motion, New York was selected as the place to hold the next annual meeting.

THE PRESIDENT—The next business in order, gentlemen, will be the report of your Committee on Machinery for the Supplying of Water Tanks, giving a description of the engine windmill, or device, and the costs of working the same.

The Secretary then read the report. On motion the report was referred back to the Committee to report at the next annual meeting.

THE PRESIDENT—Gentlemen, we have some business laid over from last year. On page 213 of our Report is the report of the Committee on Associate Membership. The names of Messrs. L. D. Bartlett, of Fitchburg, Massachusetts, and Edward Harrington, of Philadelphia, were proposed for Associate Members, and the Committee reported favorably. Afterward there was a motion made by Mr. Sprague, of Pittsburg, that the question be laid over until next meeting; the next meeting has arrived, and it should come before this meeting for action. There has also been a name presented this evening, that of Joseph G. Rogers, recommended by Mr. Towne, A. H. DeClercq,

and John Thompson. It is necessary that a committee of three be appointed, and the names referred to it, and then be balloted upon. Also, this Association has received a beautiful book of drawings, presented by Mr. Weissenborn, of New York, with a letter accompanying it, which the Secretary will read.

The Secretary then read the letter.

Letter from Mr. Weissenborn.

To the American Railway Master Mechanics' Association:

OFFICE OF AMERICAN LOCOMOTIVE ENGINEERS,
NEW YORK, May 9, 1874.

GENTLEMEN—I have this day forwarded, by express, for the acceptance of your honorable body, a volume of "American Locomotive Engineering," which is now completed in twenty-four numbers.

In doing so I desire to commend the work to your examination and kind consideration. The high reputation to which American locomotive engines have attained in all parts of the world, is due almost entirely to the genius, intelligence, and perseverance of the body of men whom your Association represents, and of these I have endeavored to make the work a representative and a monument. I hope it will prove of value in promoting a still higher pre-eminence of American locomotives, and in contributing to the general success of American railways. If it shall do so, my highest ambition will be gratified.

The work has been undertaken and prosecuted amid many embarrassments, and its successful conclusion is due largely to the assistance which I have received from Master Mechanics and Locomotive Builders in all parts of the country. Their aid has been of the greatest value to me, and is most gratefully remembered.

Trusting that your present convocation may be harmonious in its counsels, and that they will contribute to your best interests,

I am very sincerely your friend and fellow-citizen,

GUSTAVUS WEISSENBORN, *Mechanical Engineer.*

Mr. CHAPMAN, Cleveland & Pittsburg Railroad—Mr. President, I would introduce the following resolution:

Resolved, That the thanks of this Association be tendered to Gustavus Weissenborn for the very handsome volume on "Mechanical Locomotive Engineering," that he has placed in our possession, and for his courteous and excellently executed address accompanying the same.

Resolution adopted.

The President appointed on the Committee for Associate Membership, Mr. Wells, Mr. Peddle, and Mr. Garfield.

The Secretary then read the report of the Assessment Committee.

Report of Committee on Assessment.

GENTLEMEN: The Committee on Collection of Assessment beg leave to report that they have collected $1,155, as follows:

Assessment for current year	$1,110 00
Back dues	40 00
Donation	5 00
Total	$1,155 00

EDWIN GARFIELD, *H. P. & F. R. R.*,
GEORGE RICHARDS, *B. & P. R. R.*, } *Committee.*
CHAS. GRAHAM, *L. & B. R. R.*

On motion, the report was accepted.

Mr. SPRAGUE, of Pittsburg—Mr. President, for want of time I would move that the paper written by our associate member, W. W. Evans, be submitted to the Supervisory Committee, to be embodied in our report.

Carried.

ENGINEERING OFFICE OF WALTON W. EVANS,
63 PINE STREET, NEW YORK, *April* 29, 1874.

J. H. SETCHEL, ESQ., *Secretary Master Mechanics' Association:*

DEAR SIR—I have found it utterly impossible to write such papers for your Annual Convention of this year as I intended and wished to. My entire time is taken up in investigating and studying railway progress, chiefly and particularly in foreign countries; in doing this I am promoting American interests abroad, and also the railway interests of those countries using American railway "plant," and other countries which are beginning to understand the merits of the American system of railway construction, equipment, and management. You and I have no doubt but that the Association will be pleased to know that the government of Victoria, in Australia, have determined to try the American system of railway cars, and have sent to this country for specimen cars to run on the state railways of that important colony. Also, that the English Engineer and Manager of the Coquimbo Railway of Chili, having obtained from here bogies on which to mount some of his English passenger car bodies, and finding them to give great satisfaction, has ordered

bogies on which to mount his whole rolling stock of passenger carriages. The same has been tried with great satisfaction on the Mexican Railway, where they spliced with much care and skill two English carriage bodies together, and mounted them on American-made bogies. On this same railway which belongs to an English Company there are now running a large number of American-made bogie goods—cars. Recently they have been experimenting on the powers, efficiency, and economy of American engines. The reports I have received from them go to show that this company have not been led astray in their expenditure. To prove what American engines could do on a very difficult line having many sharp curves and steep gradients, an English engineer in Mexico writes a letter that I have seen, in which he says of some consolidation engines I sent last year to Mexico: "The American engines are whipping the double-bogie engines all'to pieces. They appear to be getting better all the time, while the others are getting worse. They haul eighteen, nineteen, and up to twenty-one loaded cars (each four wheels is called a car—the load is about five tons on each four wheels, exclusive of weight of car) from Vera Cruz to Orizaba, eighty-two miles, and get in thirty minutes ahead of time, while the double bogies do well if they haul eighteen and nineteen cars and get in at eleven o'clock at night, instead of half-past six, the table time." On this portion of the road there are three and one-half per cent. gradients—185 feet per mile.

The American engines have four pair of 48-inch wheels, and 89,000 pounds on them—they run with steam of 115 to 125 pounds, and cut-off at two-thirds stroke. The double bogie engines have six pairs of 42-inch wheels (three pairs in each bogie), about 163,500 pounds on drivers, use steam at full stroke, and carry a boiler pressure of 140 to 160 pounds. They are said to consume nearly double the amount of fuel and water used by the consolidation engines. I would not bring this data to your notice but for the fact that there is existing much misconception as regards the merits of the double-bogie engine. It has been very extensively puffed in all the railway countries of the world, and its pseudo inventor has declared among the leading railway men of London that the Mexican Railway could not be worked without the use of his engine. I am not a builder

of engines or interested in any locomotive works, nor have I any petty jealousy, prejudice, or interest to gratify against man or thing. My desire is to lend my efforts to the development of truth and the progress of the age in which we live, and in which railways are now playing so important a part. Whoever can add a new point and prove it, and whoever can show an error in practice in railway economy, will have done something for the general good and benefit, not only for his own people, but all people.

It has been said by some English writer that "the utilization of refuse is the measure of civilization."

I would say that the cost of carrying a ton of goods a mile, and a passenger a mile, is the true measure of railway progress and railway economy.

If national reports and railway official reports are to be relied upon there is plenty of evidence in print to show that there is not a country in the world having railways where the economy of transport of goods and passengers has been so thoroughly worked out and perfected as it has in these United States. In investigating the truth of this assertion the difference in different countries of the price of fuel, labor, and iron must be equated, but the difference in some countries is so glaring that it is not necessary to analyze the causes and make allowance for the great cost of labor and iron in this country. In Mexico, where there is a large business, the charge for transport is nineteen cents per ton per mile, and but small profit, carts and mule trains compete with the railway for the traffic. In India, according to Lieutenant-General Sir Arthur Cotton the charge is three and one-half pence per ton per mile, equal to seven cents, and not one railway making the five per cent. guaranteed by Government. In Buenos Ayres, where all the railways are in a flat, level country, one of the railway managers complains in his report that he can not make a dividend because he can not get the traffic away from the carts and the wagon trains. In this country there is much excitement in the great agricultural districts of the West and a regular howling among the "Grangers" because the railway companies will charge them one and one-half cents per ton per mile, and then make seven and eight per cent. on well watered stock. When great differences are found to exist in different countries in the way of doing

things, and in the economy resulting from one way over another, it is nothing but proper to try and dive into the reasons for these differences. In looking for the cause of the superior economy of the American railway system, we will, I think, look in vain if we expect to find it in the skill of the workmen, or the superiority of the materials used, for the English workman has a marvelous skill of hand, and most of the iron and steel we use on railways comes from England, having its cost largely added to by freight and duties. Whence, then, can come the cause which provides for our carrying a ton a mile for one and one-half cents with a good profit, and a fair chance of seeing this price reduced, but from the brains of those who are the designers, the constructors, and managers of this wonderful, extensive, and eminently successful system of railways, that is like a network over the whole country. The gentlemen of the Master Mechanics' Association are entitled to a large share of the credit due to this grand result, and I earnestly hope that some of the railway companies and some of the great railway magnates will be able to see and appreciate the labors of your Association and acknowledge it in a substantial way, so you can make your Association more and more useful every year. The railway companies should consider that the labors of this Association are chiefly for their benefit and the proper conservation of their property; they should understand that there are many points in connection with railway economy that have never yet been settled or thoroughly experimented on; that some of these experiments are costly, and beyond the financial reach of your Association and the limited time at the disposal of the members.

I have an idea that the railway interests of this country should, and I think they would if the matter were placed before them in its proper light and importance, place at the disposal of the Association the funds required to make investigations, tests, and experiments on such questions as are in doubt, and such matters as are connected with railway economy and not yet settled. I am satisfied that the railway companies would readily see, if the subject were properly brought to their attention, the vast amount of money that might be saved in the maintenance of their railways if certain questions were submitted to thorough practical experiment and scientific examination by

competent men whose brains are free from prejudices and preconceived notions which they wish to prove or disprove, and who have at their disposal the necessary apparatus and facilities. It has been proposed to establish, in connection with the Stevens Technological Institute, a laboratory containing a full apparatus for testing and examining practically all questions connected with mechanical arts and sciences. It is to be hoped that this project will not be allowed to die out. The railway companies should foster and promote it, and make it the head-quarters of all examinations in railway matters, as well as all other mechanical matters. I consider the Stevens Institute just the place for these investigations to be made, and for the following reasons:

1. It is the only institute in this country devoted to Mechanical Engineering.

2. It has a most accomplished body of professors, who have practical knowledge as well as scientific.

3. It has already a fine laboratory, containing as good, if not the best philosophical, chemical, and scientific apparatus that exists anywhere.

4. It is near to New York, the great metropolis of the country, where many questions in connection with mechanical arts and sciences would naturally center.

5. It is easily and cheaply approached from all quarters.

6. It is frequently visited by the mechanical engineers, inventors, and ingenious thinking men of the country.

Nothing is required but a little more room, a testing yard, and special tools and instruments. Those required to be added to their present superior collection of instruments are costly. Some of the examinations and experiments must be made on the lines of railways by permission of the railway companies and the use of portions of their rolling stock. A series of experiments and examinations were made about twenty years since on the London & Northwestern Railway, in connection with fuel consumption, by Messrs. Wood and Marshall, which were very interesting, and as far as English rolling stock is concerned, exhaustive, but the reports are private, and never reached the public. I have a set of these reports. Two winters since the United States Government made an appropriation of $25,000

toward furnishing a powerful testing machine for the use of the American people. This appropriation was put into the hands of the United States Ordinance Corps. Nothing has resulted from it yet that I know of. If the Stevens Institute is selected as the proper place for such examinations as are required in mechanical arts, the Government would, I think, locate this machine at the Institute. Other costly and valuable machines are required, and would in time, through the influence and assistance of railway companies, find their way to the same location, and render good service in mechanical sciences. A good, reliable, efficient and powerful dynamometer, to measure the tractive force of locomotives and the resistances of cars of different build with different loads at different speeds, and different length of trains with equal tonnage, on tracks varying in gauge and gradients, and on curves of different radii, and having different elevations of outside rail, is most required. We know pretty well what the resistances are of American rolling stock in good condition on straight lines, but we have little or no data derived from practical experiments of the resistances of loaded cars on curves of different radii at varying speeds. Without this knowledge is fixed more definitely than has yet been done, engineers are at a loss in locating railways to know how to equate gradients and curves so that the line shall be a line of economy when worked. As long as the railways were built with curves of large radii, as many railways here are, this matter was not of so much importance, but now, when we are called upon to build difficult lines with curves of 300 feet radius, this matter of resistances on curves becomes an important element to understand, not only to the engineers who construct the road, but also to the engineer who builds the engines and the engineer that has charge of their operations. I have been for over a quarter of a century connected with building some of the most difficult lines ever attempted, and I am glad to say that on these lines the American engines have exceeded my expectations, and proved their superiority on every point of merit—great utilized tractive power, small distress to the permanent way, economy of repairs, durability and efficiency under the most trying conditions of climate, snow storms, rough track on the breaking up of frost, and at great elevations—over all other engines built in other countries. The builder and great

advocate of the double-bogie engine proclaimed to the world a short time since that his engines had proved to be an eminent success in Russia. The recent order of the Councilor of Commerce in Russia to have eighty locomotives built in this country looks as if the double-bogie engine was not such a great success in Russia as was claimed for it.

In the matter of getting at reliable results from practical experiments, we owe a great deal to the English for their many extensive, costly, and valuable series of experiments. The experiments made by De Pambour, by Lardner & Woods, by De la Beche & Playfair, by Rennie & Morin, by Fairbairn, Rankine, Kirkaldy, Beattie, and the Commission appointed by the Government to examine into the uses of iron for railway structures, are all of the very first order, and most valuable to engineers. They could hardly be otherwise, as they were conducted by men of genius and great ability who were in search of the truth. I have now before me a series of most valuable experiments made by Captain White, Royal Engineer, under orders from the Government, on the Bhore Ghaut Incline in India, to determine the co-efficient of friction of brake power on that incline, which is one in forty, equal to 132 feet per mile. These experiments were conducted in a masterly way, and no doubt resulted in their being able to determine on rules to govern and control the trains in descending this long incline of the Great India Peninsula Railway, where trains had in a number of instances got beyond control and rushed down the incline to destruction, unless they were caught in the "catch-sidings" built for the purpose. I might mention in connection with this, that in English practice it is not customary to put brakes on the passenger cars, but to depend on brake-vans at the rear of the train. In working the Ghaut Incline, passenger trains hook on four to six loaded brake vans and haul them up the incline, to be used by the next train coming down, to control the speed. These vans represent forty per cent. of the weight of the train, and yet trains do sometimes get beyond control, and run away. Some years since a passenger train got beyond control on the Thull Ghaut rushed past the reversing station at a speed of seventy miles an hour, went through the stout buffers at the end of the Y as if they were chips, and made a clear jump of seventy-five feet, kill-

ing every person on the train. A similar accident happened on the Bhore Ghaut. This brake-van system would hardly satisfy American practice. In Peru and Chili, where we are working long gradients of four per cent., equal to 211 feet per mile (and on some roads there are long gradients of five per cent.—264 feet per mile), we have not experienced any difficulty in holding and controlling the trains in descending the mountain slopes, where the inclines are full of sharp curves of 350 feet radius, but we never combine this minimum curvature with any gradient steeper than three per cent. (158 feet per mile). In one instance we have a viaduct of four spans, one of the piers being 252 feet high, with a gradient of three per cent. on top, and a curve of 350 feet radius close to each end; this road has sixty-one tunnels in it, one being on the summit at an elevation of 15,722 feet above the sea, You will be pleased to know that on another line in the south of Peru we succeeded in completing, in December last, a line of railway over the main ranges of the Cordilleras, and terminated it at Lake Titicaca, an inland sea nearly 12,000 feet above the ocean. The summit of this railway is 14,666 feet above the sea. The engines that work these railways were all built in this country, and I am glad to say are giving great satisfaction. They are all Mogul and ten-wheeled engines, with 75,000 to 77,000 pounds on the drivers, and can haul 130 tons up the gradients of 211 feet per mile with certainty and ease, using steam of 125 pounds. An English engineer, who was present at the Government test of engine power, wrote me that the engines exceeded all expectations—that they were particularly remarkable on the sharp curves, which they rounded with the smoothness of a velocipede.

I intended to write answers to some questions asked in printed circulars from different Committees of the Association, but I have delayed this until I suppose it is now too late. I will merely express an opinion on some points, and would like to know the opinion of others.

The chief point I would bring to the attention of the Association is the treatment of engines by engineers—the general practice, and the rules laid down for their guidance. I see in the discussions of former years that there are some members of the Association who have a very poor opinion of steel as a material for fire boxes. I

should like to see this matter thoroughly investigated to prove whether steel as a metal for fire boxes is poor, or if the treatment of steel fire boxes is poor. You have shown in one of your reports that certain steel fire boxes, made when steel was first used for the purpose, had stood a service much greater than that of any fire box made of copper or iron. If very superior results were obtained when steel was first used, why can not the same be obtained now? From investigations I have made, and from the knowledge I have of the nature and quality of steel, I am convinced that steel is by all odds the best material for fire boxes, and that when steel fire boxes are properly made by experienced workmen, and the sheets properly annealed to take all undue strains out of them before riveting, there need be no fear for their safety, endurance, and economy if properly handled. I fear that the difficulties of sheets cracking complained of by some Masters of Motive Power is due to bad treatment, treatment that changes the character of the steel, and makes it, from being soft and ductile, hard, brittle, and crystalline, it is then ready to crack when struck, and sometimes does crack without being touched. My impression is that this chemical and physical change in the steel is produced entirely by blowing off the engine while hot, and allowing it to stand in currents where it cools quickly; also from a pernicious practice I have seen of throwing a bucket of water in a fire box to put out a fire. There is not a fire box of any kind that would not be injured and eventually ruined by such practice—there is not a steel fire box in existence that would not be soon brought to ruin by this kind of treatment. The best kind of treatment to give to all engines, and particularly engines with steel fire boxes, is to let them cool gradually with all their water in them and with fire door and dampers closed, and as much done as possible to prevent rapid radiation of heat. Now, how close can we come to this. The members of the Association can determine this better than I can. I think some will say this is impossible with the bad water we use, and the frequent blowings off that become necessary, we would require double the number of engines we now have. I do not say that the matter of never blowing off while hot can be attained, but I do say that the injury resulting from blowing off hot can be proved to the satisfaction of any one; that the matter can be kept in mind and carried out in

practice as far as possible; and that the frightful practice of throwing buckets of cold water in fire boxes of any kind can and should be put a stop to; and that when an engine is blown off hot it can be run out of cooling currents, it can have its fire door and dampers closed, and as much as possible prevent currents of cold air being drawn through the fire box and flues.

There are but few engine men, I suppose, who have not seen the evil effects produced in a short time by opening the fire door of a furnace when the fire was in great activity, and letting a cold current strike against the tube sheet. We all know that if a cast-iron car wheel is taken from the mold soon after being cast, and thrown on the surface to cool, it will be worthless and break the first time it is used; a cast-iron cannon is the same—worthless if not cooled very slowly. I beg you to excuse me for saying so much on this subject; I may be saying what all know and appreciate—namely, the importance of using good water; the importance of blowing out as little as possible; the importance of never blowing off hot when it can be done cold; the importance of never overworking an engine, if economy is an object in managing the motive power of the railway.

Having been for a long time convinced of the poor character of many of the steam-pressure gauges made in this country; that all of them become weak in time; that those which are sold at the lowest price are the most patronized, without much regard to real value or reliability; and knowing the importance of a good and true gauge, particularly in working difficult lines; and believing that a reliable test gauge would be a valuable instrument for every Master of Motive Power to have in his office, I submitted the matter with drawings of a test gauge to Mr. D. P. Davis (a manufacturer of a superior steam-pressure guage), with a request that he would manufacture for me a test gauge that should not depend on a spring; that should be accurate and reliable; that should not occupy much space; that should not easily get out of order, and that should not exceed in price a sum that would allow of its coming into general use. Mr. Davis has spent much time, ingenuity, and money, in the production of a reliable test gauge. His first efforts were not attended with success, finding it impossible to make the work so accurate that the

liquid used to transmit the pressure would not, at high pressures, get between the plunger and the walls of the cylinder, he has by the introduction of a small india-rubber diaphragm at the foot of the plunger and between it and the pump, cut off all connections of the liquid and the plunger, and succeeded in making a reliable test gauge which depends on levers, knife-edges, and standard weights, the lever being graduated directly from a mercury column. I believe that this test gauge meets the conditions named above, and that it will supply an important want in the office of Master Mechanics. I hope that Mr. Davis will bring his instrument to the attention of the Convention, and that it will meet with the patronage I think it deserves.

It strikes me that there is another want not yet supplied in working our railways. It is a small book containing rules and regulations for the guidance of engine men; in the running and conservation of engines, particularly as regards reversing suddenly; starting with a jump; oiling without waste; the evil effects of sudden changes of temperature; accuracy in setting valves and the adjustment of all working parts; making steam joints, and packing, priming, and incrustations—the evils of, and how to remedy them; the conversion of fuel into heat-producing gases; the transmission of heat; the care required in descending steep gradients; how to meet difficulties that may occur, and many other points. I think that a small book of this kind, written in such a way that any man of intelligence can understand it, got up and approved of by a committee of your Association appointed for the purpose, would result in much good to railway interests. I would not bring this matter to your attention but for the fact that I have seen valuable and costly machines intrusted to men who were utterly ignorant of how to handle them with care and economy. There is, besides costly machines, more responsibility of life and limb intrusted to engineers than to any other class in the country. If we would pay more attention to their education and social condition we would have to pay less for work done in the repair shop. One of the great works of this country takes just pride in showing that one of their engines had run 153,000 miles without being lifted from its wheels. I find by the reports of the Pennsylvania Railway for 1872, that one of their engines No. 133,

ran 83,820 miles in the year; this is nearly 230 miles a day for every day in the year. I wonder how many miles their engines would have run if they had been in the hands of slip-shod, dram-drinking, half-educated engine men. Many little things that can be easily and quickly learned, if properly taught, are left to men to find out the best way they can. I speak from experience; for in the early days of my engineering career I was left, for years, to find out by myself certain points in the adjustments and optics of mathematical instruments that could have been taught to me in a few minutes by an experienced man, or by a small book of rules and instructions.

I notice that one of the circulars calls for the consumption, kind, and cost of fuel per mile, and weight of train hauled on different roads. To make comparisons of engine performance, and fuel burnt on different roads, with different gradients and curves, different speeds and climate, is a very difficult thing to do. It appears to me that the best way to obtain data that will be of value to your Association would be for each railway to find out the "foot-pounds" of work required to carry a ton over each mile of their railways, in each direction at different speeds, to make a table of these amounts for each mile, and totals for divisions, and for the whole road, and arrange them so that quantities can be taken from the table easily to represent the work done by any train at any average speed.

One of your circulars refers to supplying water-tanks, and the use of windmills. I beg to bring to your attention the importance of windmills and the economy resulting from their use. I have used a number of pumping windmills made by the Empire Windmill Co., of Syracuse, and have in every instance been very well satisfied with their performance; they are not costly or difficult to erect. I have one at my country place, which has been in use about six years; it has cost nothing for repairs; I use it to pump water from a deep well into a reservoir in the top of my house; it generally gets hrough with its day's work in an hour, when it is stopped. I had globe oilers attached to each journal, which provides good lubrication without care for about a month, when my coachman cleans journals and oilers, and fills them. This mill will work sometimes when the currents of air will hardly disturb the leaves of the trees. It is at the op of a yellow pine timber 54 feet high, held in position by

guys. If at any time it is required, these windmills can be unhooked and the pumps worked by ordinary hand-brakes.

I would recommend the use of submerged pumps, which do not depend on packing.

It appears to me that the Brayton Ready-Motor will come in play, and render good services at water-stations, as soon as the inventor will make it double-acting and capable of keeping its lamps lit when the engine is stopped. It will, I think, be a proper and economical engine to apply to such small cars as are now used on railways and run by hand for the following reasons: It has no boiler; it can be run by any man with a few minutes' instruction; it is not heavy or complicated; it can be set in full motion and power within fifteen seconds after its fire is lit; it is a gas and air engine; it can make its own gas from a can of napthaline standing by it; it can produce a horse power at about the same price it costs to produce the same with a steam engine; when it is turned off, all expense stops, as a considerable amount of heat is produced by burning the gas; this heat might be all saved by carrying the exhaust-pipes of pumping engines through and coiled in the water reservoirs at stations.

Heating water at stations by fires built expressly for the purpose is a matter worthy of consideration in studying the economy of motive power, particularly in cold climates during the winter season. At all stations, rooms for various purposes are required, which are heated by stoves in winter. These rooms might be under water reservoirs, with coils of pipe running through the water and around the fire in the stove, as Perkins builds his water-heating apparatus in London. This water-pipe is a continuous coil with no ends or openings; it is filled with water; the same water circulates in it from one end of the year to another, taking up increments of heat in passing through the coil in the fire, and giving them out when it passes through the coil in the water. I have seen these pipes in Perkins' works in London under pressure of 2,000 pounds to the square inch. I have seen Perkins' men, in making portable ovens for the English army, take gas-pipes 13 feet long, weld up one end, put three pints of water in it, and then weld up the other end—a series of these pipes forming an oven, the section being like that of a gas retort. It appears to me that heating water at stations might

result in more economy than at first sight is evident. It must be recollected that the furnace of a locomotive is an expensive structure; that its life might be measured by the units of heat passed through it; and that every unit of heat that we can give to the water before it goes in the boiler is so much saved, and the distress to the furnace so much reduced. In examining the matter of hot water engines (engines to be run without fires) for the Central Underground Railway of this city, so as to get rid of carbonic acid gas in the tunnels and provide good ventilation, I was astonished to find how heat could be stored in water and held subject to draft. I send with this a copy of that report.* As some of the figures may be interesting to members of the Association, they will be found in Appendix A. You will see that I propose to use pressures of 500 pounds to the square inch in the boilers. I would not propose this except under very extraordinary conditions, such as are met with in an underground railway with very few openings, and requiring very many large trains to be run at short intervals of time.

I am, dear sir, yours most sincerely,

W. W. EVANS,
Associate Member M. M. Association.

Mr. WHITE, Evansville & Crawfordsville Railroad—There was a little mistake made by the Secretary in reading that report on Water Supplies. I have not had an opportunity to confer personally with either of the members of the Committee, and the latter part of that was written out hastily, and I concluded I would not have it read—that is about the page read last. Last night I wrote a few lines recommending that the subject be laid over, and a new committee appointed to continue it. I would like Mr. Setchel now to commence, read back a little, and then to read a little pencil sketch I gave him yesterday.

Mr. SETCHEL, Little Miami Railroad—By way of explanation, I will say that what Mr. White has stated is correct. By accident I omitted that part of the report written on a separate piece of paper in pencil. The latter part of the report was left out and not signed, because, as he states, of not being submitted to the rest of the Committee. The part in pencil being lost I can not comply with Mr. White's request. The report is referred back to the Committee.

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*See Engineer's Report of New York City Central Underground Railway, Appendix A.—SECRETARY.

THE PRESIDENT—The report of the Narrow and Broad Gauge Rolling Stock Committee is now in order.

The Secretary then read the report, which, on motion, was accepted.

Report of Committee on Narrow and Broad Gauge Rolling Stock.

To the American Railway Master Mechanics' Association:

GENTLEMEN—Your Committee on the subject of Narrow and Broad Gauge Rolling Stock, beg leave to report that they framed the following questions, which were submitted to the various Master Mechanics of the Association, requesting answers:

1. What is the gauge of your road?
2. What is the diameter of cylinders, length of stroke, number and diameter of driving and truck wheels, and gross weight of each class of engine on your road?
3. What is the gross load hauled by each class of engine (including engine and tender), pressure of steam, point of cut-off grades, curves, speed in miles per hour, also the dead weight carried per ton of paying weight in each case? Give also the kind of tires, plain or flanged, and their position on the engine.
4. What is the weight of each class of freight cars, four and eight wheeled, and the loads they actually carry? Give weights and loads carried by each class.
5. Give also the cost of repairs of engines per mile.

The substance of the replies received are embodied in the sheets accompanying and forming part of this report; they have also included a column showing the comparative tractive power developed in each case as compared with the dead weight of engine and tender. Engine frictions are taken at eighteen pounds, and tender and car frictions at eight pounds per ton.

[illegible]

TABLE OF COMMITTEE ON NARROW AND BROAD GAUGE ROLLING STOCK.

Ripley Narrow Gauge, 3 feet, Memphis & Charleston Railroad.

Class of Cars.	Description of Train.	Length.	Width.	Weight	Load.	No. and diameter of wheels.	Proportion of dead weight to paying load of cars.
Passenger Cars	Passenger			15,000	5,250		2.85 to 1
Baggage and Express Cars	Passenger			10,500	8,000		1.312 " 1
Coaches	Mixed			15,000	3,000		5. " 1
Baggage Cars	Mixed			10,500	1,500		7. " 1
Box Cars	Mixed			8,500	7,000		1.214 " 1
Platform Cars	Mixed			6,500	9,500		0.684 " 1
Platform Cars	Freight			6,500	8,000		0.81 " 1
Box Cars	Freight			8,500	8,666		0.98 " 1
Box Cars	Heaviest load, freight			8,500	12,000		0.708 " 1
Platform Cars	Heaviest load, freight			6,500	12,000		0.541 " 1

Toronto, Grey & Bruce Railroad, Gauge 3 feet 6 inches.

Small Box Cars		15 feet.	8 feet 0 in.	7,500	12,000	4...24 in.	0.625 to 1
Large Box Cars		29 "	8 " 0 "	16,000	20,000	8...30 "	0.8 " 1
Short Platform Cars		18 "	7 " 6 "	6,000	12,000	4...24 "	0.5 " 1
Long Platform Cars		30 "	8 " 0 "	11,500	20,000	8...30 "	0.57 " 1

TABLE OF COMMITTEE ON NARROW AND BROAD GAUGE ROLLING STOCK.—CONTINUED.

Class of Cars.	Description of Train.	Length.	Width.	Weight	Load.	No. and diameter of wheels.	Proportion of dead weight to paying load of cars.
Toronto & Nipissing Railroad, Gauge 3 feet 6 inches.							
Large Box Cars		30 feet.		15,500	20,000	8...30 in.	0.775 to 1
Large Platform Cars		30 "		11,500	20,000	8...30 "	0.575 " 1
Short Box Cars		18 "		9,000	10,000	4...24 "	0.9 " 1
Short Platform Cars				6,000	10,000	4...24 "	0.6 " 1
Eastern Kentucky Railroad, Gauge 4 feet 8½ inches.							
Long Box Cars				16,000	21,000	8	0.761 to 1
Short Box Cars				6,800	10,000	4	0.68 " 1
Platform Cars				14,000	20,000	8	0.7 " 1
Flint & Pere Marquette Railroad, Gauge 4 feet 8½ inches.							
Box Cars				20,000	20,000	8	1. to 1
Flat Cars				15,000	20,000	8	0.75 " 1

St. Louis, Vandalia, Terre Haute & Indianapolis Railroad, Gauge 4 feet 8½ inches.

Box Cars	....	....	....	19,000	20,000	8........	0.95 to 1
Coal and Flat Cars	....	....	....	15,000	24,000	8........	0.625 " 1
Cattle Cars	....	....	....	18,000	24,000	8........	0.75 " 1
Express Cars	....	....	....	28,000	10,000	....	2.8 " 1
Baggage Cars	....	....	....	32,000	8,000	....	4. " 1
Sleeping Cars	....	....	....	58,000	3,000	....	19.33 " 1
Coaches	....	....	....	38,000	5,500	....	6.9 " 1

Lackawanna & Bloomsburg Railroad, Gauge 4 feet 8½ inches.

Coal Cars	....	....	....	7,000	13,700	4........	0.51 to 1
Gondola Cars	....	....	....	15,000	22,400	8........	0.625 " 1
Box Cars	....	....	....	17,000	22,400	8........	0.758 " 1

Central Railroad of New Jersey, Gauge 4 feet 8½ inches.

Coal Cars	....	....	....	6,000	12,320	4........	0.487 to 1

Mejia & Arequipa Railroad, Peru, S. A., Gauge 4 feet 8½ inches.

Long Flat Cars	....	....	....	14,500	20,000	8...30 in.	0.725 to 1

TABLE OF COMMITTEE ON NARROW AND BROAD GAUGE ROLLING STOCK.—Continued.

Copiapo Extension Railroad, Chili, S. A., Gauge 4 feet 8½ inches.

Class of Cars.	Description of Train.	Length.	Width.	Weight	Load.	No. and diameter of wheels.	Proportion of dead weight to paying load of cars.
Short Cars				4,000	6,000	4	0.66 to 1

Jeffersonville, Madison & Indianapolis Railroad, Gauge 4 feet 8½ inches.

Class of Cars.	Description of Train.	Length.	Width.	Weight	Load.	No. and diameter of wheels.	Proportion of dead weight to paying load of cars.
Box Cars				19,900	20,000	8	0.995 to 1
Coal and Flat Cars				15,000	20,000	8	0.75 " 1

Memphis & Charleston Railroad, Gauge 5 feet.

Class of Cars.	Description of Train.	Length.	Width.	Weight	Load.	No. and diameter of wheels.	Proportion of dead weight to paying load of cars.
Express Cars	Passenger			18,000	10,000		1.8 to 1
Baggage Cars	Passenger			31,000	6,000		5.16 " 1
Mail Cars	Passenger			33,000	2,000		16.5 " 1
Passenger Cars	Passenger			39,000	6,000		6.5 " 1
Sleeping Cars	Passenger			60,000	5,200		11.5 " 1
Box Cars	Freight	34 feet.	9 feet 6 in.	22,500	22,500		1. " 1

Pittsburg, Fort Wayne & Chicago Railroad, Gauge 4 feet 9¼ inches.

Box Cars	....	....	....	17,000	20,000	8........	0.85 to 1
Stock Cars	....	....	....	17,000	20,000	8........	0.85 " 1
Flat Cars	....	....	....	14,410	20,000	8........	0.72 " 1

Great Western Railroad of Canada, Gauge 5 feet 6 inches.

Box Cars	....	....	....	20,000	20,000	8........	1. to 1
Platform Cars	....	....	....	14,000	20,000	8........	0.7 " 1

Atlantic & Great Western Railroad, Gauge 6 feet.

Box Cars	....	....	....	18,000	18,000	8........	1. to 1
Box Cars	....	....	....	18,000	24,000	8........	0.75 " 1
Stock Cars	....	....	....	21,000	18,000	8........	1.166 " 1
Stock Cars	....	....	....	21,000	24,000	8........	0.875 " 1
Gondola Cars	....	....	....	17,000	18,000	8........	0.944 " 1
Gondola Cars	....	....	....	17,000	24,000	8........	0.708 " 1
Flat Cars	....	....	....	16,500	18,000	8........	0.901 " 1
Flat Cars	....	....	....	16,500	24,000	8........	0.687 " 1

Southern Railroad of Chili, S. A., Gauge ——.

Flat Cars	....	28 feet.	8 feet.	14,700	22,400	8...33 in.	0.656 to 1

TABLE OF COMMITTEE ON NARROW AND BROAD GAUGE ROLLING STOCK.—CONTINUED.

Average Proportion of Dead to Paying Weight for all Gauges less than 4 feet 8½ inches.

Class of Cars.	Description of Train.	Length.	Width.	Weight	Load.	No. and diameter of wheels.	Proportion of dead weight to paying load of cars.
All Coaches, Baggage, Mail and Express Cars	....	....	....	....	....	....	2.873 to 1
All Freight Cars	....	....	....	....	....	....	0.7065 " 1
Highest Proportion	Ripley Narrow Gauge	....	....	....	....	....	1.214 " 1
Lowest Proportion	Toronto, Grey & Bruce	....	....	....	....	....	0.5 " 1

Average Proportion of Dead to Paying Weight for all Gauges of 4 feet 8½ inches and the wider Gauges.

Class of Cars.	Description of Train.	Length.	Width.	Weight	Load.	No. and diameter of wheels.	Proportion of dead weight to paying load of cars.
All Coaches, Baggage, Mail, Express and Sleeping Cars	....	....	....	....	....	....	4.454 to 1
All Freight Cars	....	....	....	....	....	....	0.8017 " 1
Highest Proportion	Atlantic & Gt. Western	....	....	....	....	....	1.166 " 1
Lowest Proportion	Central of New Jersey	....	....	....	....	....	0.487 " 1

Colorado Central Railroad, Gauge 3 feet.*

Class of Cars.	Description of Train.	Length.	Width.	Weight	Load.	No. and diameter of wheels.	Proportion of dead weight to paying load of cars.
Freight Cars	....	....	....	8,500	12,000	....	0.7083 to 1

*Reported too late for classification.

All of which is respectfully submitted,

WM. S. HUDSON, *Rogers Locomotive Works,*
H. N. SPRAGUE, *Locomotive Builder, Pittsburg,* } *Committee.*

Mr. HUDSON, Rogers Locomotive Works—Mr. President, I wish to say a few words in regard to that report. While the dead weight of the cars on the narrow gauge is generally less than it is on the ordinary or standard gauge, there are individual cases where it is less on the standard than on the narrow gauge. So also of the power of locomotives in proportion to their weight. The lowest or the one showing the greatest amount of efficiency in proportion to its weight is on the standard gauge; therefore there is nothing to say in favor of the narrow gauge, but rather against it. It will be noticed that the speed on the narrow gauge is from ten to twelve miles per hour, while on the ordinary gauge it is from fifteen to thirty and thirty-five miles an hour. Of course, the circumstances being very different you can hardly make a fair comparison; and the column in the report, showing the tractive power of the engine in its operation with dead weight, is in order to afford a better standard of comparison. Where engines are worked under various circumstances of speed and curves you have hardly anything with which you can make a fair comparison. You need to reduce them to one kind or standard in order to compare them, and there is a column carried out in that paper which will enable persons to arrive at a definite conclusion. I had written some remarks that I intended to inflict upon the Association, but as the time is late I will not offer them.

Mr. SPRAGUE, of Pittsburg—Mr. President, inasmuch as narrow gauge roads are in their infancy, and as we have started out to get information in regard to the construction of the rolling stock, we have had considerable to contend with and we have failed to get reports from two of the oldest narrow gauge roads in the United States—having a report only from two roads, one of which has an exceptionally heavy grade and curves. Consequently, our report is very imperfect and does not give a fair showing of the results of narrow gauge roads.

Mr. HUDSON, Rogers Locomotive Works—Mr. President, I might be allowed to state further, in regard to a statement that I believe was made in our last Convention, to the effect that narrow gauge roads were far better than ordinary gauges, and that locomotives could be built to do the same work far cheaper on narrow gauge roads than they could on ordinary gauges. Well, I take exception to that, not only as a locomotive builder but as a locomotive engineer. In my practice in building locomotives I think I have built as large locomotives for the narrow gauge as have been built. For instance, engines with cylinders fifteen by eighteen, and six thirty-six inch wheels, on a two foot six inch gauge; and I have also built one form of locomotive having a cylinder three and one-half feet by ten inches, and drive wheels of thirty inches, with four feet eight and one-half inch gauge. I think there is variation enough to show that light stock can be made for the ordinary gauge. We can make as light engines and cars, and put down as light rails for an ordinary gague as we can for a narrow gauge. Now, the

Festenock road, the oldest road in Wales, is held up as a pattern of all these gauges in England, yet the expenses of working the road is double what it is on most ordinary gauges in England. That road is held up as a sample of the narrow gauge. In the distance of two feet around curves the outward rail is raised three inches, to enable them to get around without having the cars turn over.

Mr. JACKMAN, Chicago, Alton & St. Louis Railroad—Mr. President, I wish that we had the time to discuss this matter, but I will detain you only a moment. I hardly believe that it is the sense of this Association that the narrow gauge can be worked cheaper than the four feet eight and one-half gauge, doing the same business, at the same rate of speed.

Mr. SPRAGUE, of Pittsburg—Mr. President, I would say that I am very sorry we can not get this subject before the Convention another year as a subject for debate.

Mr. FORNEY, Railroad Gazette—Mr. President, I would like to say to Mr. Sprague that it is entirely in order for him to move the continuance of the subject, if he desires it to be continued. Of course, it is right and proper that he should make such a motion. I do not want the *onus* of suppressing this subject.

Mr. SPRAGUE, of Pittsburg—Mr. President, I would say that I can not see that the members of the Convention take a very decided interest in the matter. I attempted to prevail on Mr. Hudson to continue on the Committee another year, and not to report this year, so as to get some results to make a report with that would be satisfactory, but he did not choose to continue on the Committee for another year, and as it was getting late, I knew it would take time to reorganize the matter.

Mr. FORNEY, Railroad Gazette—I would then, Mr. President, move that the subject be continued.

Mr. JEFFREY, Illinois Central—And referred to the same Committee.

THE PRESIDENT—It can not be done if one of them has resigned.

Mr. HUDSON, Rogers Locomotive Works—Mr. President, I will state this much: Mr. Sprague came to me and stated we had better not report at all until next year, and he wanted to know if I would like to do so. I said *no!* If the Association don't choose to receive the report, they must not continue me on the Committee. Now, if they choose to have a committee appointed to take the subject into consideration for another year, I have nothing to say about it; but I say, when you appoint a Committee, and they take pains to collect information, and come here to tender it, I think it is nothing but right that it should be received. You can say you won't receive it, if you choose, but I think that is hardly fair.

THE PRESIDENT—I will place the gentleman right, as I see there is a misunderstanding. The report has been received already and ordered printed some time ago. Now, there is another motion before the Convention.

Mr. HUDSON, Rogers Locomotive Works—Mr. President, I understand that; but I merely stated what I have in explanation, or in reply to what Mr. Sprague said about my refusing to serve on the Committee. I did refuse to serve if the report was not received.

Mr. LILLY, of Indianapolis—Mr. President, I consider that the report contains very valuable information, and I, for one, would like to see it printed.

Mr. SPRAGUE, of Pittsburg—Mr. President, I simply took the course I did in order to save time of the Convention. I am aware that the report is very imperfect; we could not get the information we should have, or what we could get, in another year. As far as I was concerned, I was willing to say to the Convention that the report was imperfect, and to save the time that would be occupied in reading the report move that it be referred to the Committee on that subject for the next year.

The motion that the subject of the Narrow and Broad Gauge Rolling Stock be continued, was carried.

THE PRESIDENT—As one of the Committee has withdrawn from our Association, there will be another one appointed in his place.

The Secretary then read the report of the Committee on the application of Dr. Rogers, for Associate Membership, which report was accepted.

To the American Railway Master Mechanics' Association:

GENTLEMEN—We, the Committee to whom was referred the petition of Dr. Joseph G. Rogers, for Associate Membership in our Association, beg leave to report favorably on his application.

REUBEN WELLS,
CHARLES R. PEDDLE, } *Committee.*
EDWIN GARFIELD,

On the ballot of the Convention, Dr. Joseph G. Rogers was admitted as an Associate Member.

THE PRESIDENT—Gentlemen, the applications of L. D. Bartlett, of Fitchburg, and Edward Harrington, of Philadelphia, whose names were proposed last year for Associate Membership, were laid over for one year. What action will you take upon them?

Mr. SPRAGUE of Pittsburg—Mr. President, I am not particularly acquainted with the gentlemen; but from what I know of one of them, although I think a great deal of him as a man, I do not think he is a proper man for a member of this Association. I think we ought to go against too many Associate Members.

On motion, the applications of L. D. Bartlett and Edward Harrington were laid on the table for one year.

THE PRESIDENT—The next business in order, gentlemen, is the election of officers. The first step in the election is the appointment of two tellers.

I will appoint for such tellers Mr. James Sedgely, of the Lake Shore Railroad, and John Thompson, of the Eastern Railroad. The Constitution provides that the officers shall be elected for the term of one year. The members will now prepare their ballots for President, for the ensuing year.

Mr. JACKMAN, Chicago, Alton & St. Louis Railroad—Mr. President, I would suggest, if it is legal, that the same officers who have been in office for the year past, be continued for the next year.

Mr. FELLOWS, Lake Shore & Tuscarawas Valley Railroad—I think, Mr. President, we can overcome any legal objection by making a motion that Mr. Jackman cast the vote of this Convention, for the election of its present incumbents to the same offices for the ensuing year, if that can be done.

Mr. JEFFREY, Illinois Central Railroad—I move that we postpone the election of officers for one year.

Carried.

Mr. ROBINSON, Great Western Railroad—Mr. President, I beg to offer the following resolution:

Resolved, That the thanks of this Association be presented to the Chicago Committee and others, who have contributed so courteously and liberally to the entertainment of ourselves and lady friends.

Carried.

Mr. WELLS, Jeffersonville, Madison & Indianapolis Railroad—Mr. President, I have the following resolution which I wish to offer:

Resolved, That the special thanks and appreciation of the Association be tendered to the proprietors of the Sherman House, for their attention and courtesy in connection with the requirements and necessities of the members of the Association, and their lady friends.

Carried.

Mr. ROBINSON, Great Western Railroad—Mr. President, I beg to recommend that the same Committee who shall act as Supervisory Committee, shall act as Printing Committee, as there is very little now to be done by the Printing Committee, in consequence of the Secretary having a report, embracing nearly all the subjects coming under that head, and as that comes under the supervision of the Supervisory Committee I think that the Printing Committee and the Supervisory Committee should be the same; so that all that is necessary to be done, I think, Mr. President, is to appoint the Supervisory Committee, covering the duties of Printing Committee also.

A motion providing that the Supervisory Committee be empowered to attend to the Printing, and that they consist of officers of the Association, was carried.

The President then announced the following as the new Committees, and those holding over for the ensuing year:

COMMITTEES AND SUBJECTS FOR DISCUSSION AT THE EIGHTH ANNUAL CONVENTION.

1.

The Best Material, Construction, Operation, and Management of Locomotive Boilers.

J. M. BOONE, Pittsburg, Ft. Wayne & Chicago;
J. A. JACKMAN, Chicago, Alton & St. Louis;
G. W. CUSHING, Chicago.

2.

Purification of Feed Water.

Committee to report what methods, up to this time, have been most approved for the improvement of feed water by chemical and mechanical means, and for the prevention of incrustation.

H. A. TOWNE, Northern Pacific;
COLEMAN SELLERS, Philadelphia;
H. ELLIOTT, Ohio & Mississippi;
WM. WILSON, Chicago, Burlington & Quincy;
H. V. FARIES, Atchison, Topeka & Santa Fe.

3.

Locomotive Tests.

This Committee to request members to make experimental tests to show the performance of locomotives, and to report the results to this Association.

M. N. FORNEY, Railroad Gazette;
R. A. THURSTON, Stevens' Institute;
W. WOODCOCK, Central, of New Jersey.

4.

Locomotive Construction.

This Committee to report, as far as possible, all new methods of construction which have been adopted by members during the past and coming year.

J. SEDGLEY, Lake Shore & Michigan Southern;
L. S. YOUNG, Cleveland, Columbus, Cincinnati & Indianapolis;
HOWARD FRY, late Erie.

5.

The Best System of Signals for Operating Railroads.

Subject to include train-head signals, train-tail and side signals, road or station-switch signals, and appliances for indicating the speed of trains.

JOHN THOMPSON, Eastern;
A. B. UNDERHILL, Boston & Albany;
JNO. ORTTON, Great Western, of Canada.

6.

Locomotive and Tender Wheels.

This Committee to report breakages of wheels and tires, removals of tires, and cause of breakage or removals, and to report on the different methods of construction and manufacturing of various kinds of engine and tender wheels.

J. N. LAUDER, Northern, of New Hampshire;
G. W. STRATTON, Pennsylvania;
S. A. HODGMAN, Philadelphia, Wilmington & Baltimore.

7.

Construction and Improvements of Continuous Train Brakes During the Ensuing Year, and their Application to Cars and Locomotives.

CHAS. R. PEDDLE, St. Louis, Vandalia & Terre Haute;
F. GOULD, Missouri, Kansas & Texas;
GEO. RICHARDS, Boston & Providence.

8.

Lubricants for Locomotives.

F. B. MILES, Philadelphia;
H. D. GARRETT, Pennsylvania;
EDWIN GARFIELD, Hartford, Providence & Fishkill.

9.

Boiler Explosions.

Committee to attend the experiments to be made by the Government in regard to boiler explosions, and to report to the American Railway Master Mechanics' Association.

Committee to attend experiments to be made at Sandy Hook:

H. M. BRITTON, Cincinnati & Whitewater Valley;
A. B. UNDERHILL, Boston & Albany;
H. L. BROWN, late Erie;
J. H. FLYNN, Western & Atlantic;
THOS. KERR, Camden & Amboy;
W. A. ROBINSON, Great Western, of Canada.

Committee to attend experiments to be made at Pittsburg or Cincinnati:

H. M. BRITTON, Cincinnati and Whitewater Valley;
REUBEN WELLS, Jeffersonville, Madison & Indianapolis;
CHAS. R PEDDLE, St. Louis, Vandalia & Terre Haute;
J. H. SETCHEL, Little Miami;
S. M. CUMMINGS, Pittsburg, Ft. Wayne & Chicago.
N. E. CHAPMAN, Cleveland & Pittsburg.

10.

Standard Axles.

M. N. FORNEY, Railroad Gazette;
COLEMAN SELLERS, Philadelphia;
GORDON H. NOTT, Boston.

11.

Narrow and Broad Gauge Rolling Stock.

W. S. HUDSON, Rogers Locomotive Works;
H. N. SPRAGUE, Locomotive Builder, of Pittsburg.
H. G. BROOKS, Brooks' Locomotive Works, Dunkirk.

12.

Machinery for Supplying Water to Tanks, Giving Description of Engine, Windmill, or Device, with Cost of Working the Same.

J. L. WHITE, Evansville & Crawfordsville;
J. H. FLYNN, Western & Atlantic;
HOWARD FRY, late Erie.

13.

Mechanical Laboratory.

Committee to take into consideration the propriety of establishing a Mechanical Laboratory.

W. A. ROBINSON, Great Western, of Canada;
REUBEN WELLS, Jeffersonville, Madison & Indianapolis;
J. M. BOONE, Pittsburg, Ft. Wayne & Chicago;
N. E. CHAPMAN, Cleveland & Pittsburg;
H. M. BRITTON, Cincinnati & Whitewater Valley.

14.

Finance.

J. W. PHILBRICK, Maine Central;
THOMAS KERR, Camden & Amboy;
WILLIAM McALLISTER, West Jersey.

15.

Trustees of Boston Fund, Printing, and General Supervisory Committee.

H. M. BRITTON, Cincinnati & Whitewater Valley;
N. E. CHAPMAN, Cleveland & Pittsburg;
W. A. ROBINSON, Great Western, of Canada;
J. H. SETCHEL, Little Miami.

16.

Arrangements for Next Annual Meeting.

H. G. BROOKS, Brooks' Locomotive Works;
W. M. STRONG, New York & Harlem;
J. VAN VETCHEN, Erie.

THE PRESIDENT—Before we adjourn I want once more to appeal to the members to answer the circulars of the committees this year, and to answer them promptly. I know, from the reports that have been presented here, that very few replies to their questions have been given. It seems as though we ought to start anew this year, and answer all the committee circulars that are sent out.

Mr. WOODRUFF, Central Railroad, of Iowa—What time is appointed for next meeting?

THE PRESIDENT—The Constitution calls for it to be held the second Tuesday in May.

Mr. JACKMAN, Chicago, Alton & St. Louis Railroad—Now, Mr. President, as you recollect, over in the hall to-day I told you that for the future, if the higher powers would assist me, I would try and be faithful to the Association, and that so far as these circulars are concerned I would answer their questions. I am determined, for one, for the year to come, to answer every circular that comes to me, and I hope all the committees will send them to me; and I will furthermore promise that I will give them my best attention, and answer them to the best of my ability, and that my answers shall not be simply yes and no, but I will go into the discussion of the subject and discuss it as fully as I possibly can. This I promise, for one. I do not know how it is with the others, but I hope they will all do the same. Then when these reports come in which have cost the committee a great deal of labor, and embrace a great deal of very useful information, we want to discuss them most thoroughly before we print them and send them out to the world as our opinions. That is a thing necessary to be done, and I hope we shall do it. That was one reason why I did not want to send out this report on the Broad and Narrow Gauge. I do not believe this Convention wants to give it as its opinion that the narrow gauge railway, with the extreme narrow gauge, can be run cheaper, and the transportation can be done better, more successfully with that than upon a gauge of four feet eight and a half inches.

THE PRESIDENT—Another request I would make, is, that each of the Chairmen of the committees will add to his circular the time by which he wants the replies sent to him, so that they will get their report written in time.

Mr. HAYES, Illinois Central Railroad—Mr. President, I would suggest that the Supervisory Committee have circulars printed with the subjects, so that each of the Chairmen of committees can get his circulars out to the members early in the season. We can devote more time to the labor of answering these circulars in warm weather than we can in the winter. Last year I did not get them until about Christmas, and I did not have time, and hence I did not answer but few of them.

THE PRESIDENT—I will state, Mr. Hayes, that in all probability the circulars of the committees will be furnished very early this year on account of our getting our manuscript so early. It was not the case last year. I also wish to remind the Convention that we have had our proceedings very promptly and fairly reported in the press of this city, and I hope some action will be taken upon it. I hope, too, that next year we will not think best to have less than a four days' session—Tuesday, Wednesday, Thursday, and Friday. It crowds our business a little too much, and it is rather hard work for the committees to have so few sessions.

Mr. Forney, Railroad Gazette—Mr. President, I move that a vote of thanks be tendered to the press of Chicago for the very excellent report of our sessions which they have published.

Carried.

Mr. Sprague, of Pittsburg—Mr. President, I move that we now adjourn.

The Convention then adjourned.

CONSTITUTION

AS AMENDED AT SIXTH ANNUAL MEETING, BALTIMORE, MAY 13, 1873.

PREAMBLE.

WE, the undersigned, Railway Master Mechanics believe that the interests of the Companies by whom we are employed may be advanced by the organization of an Association which shall enable us to exchange information upon the many important questions connected with our business. To this end do we establish the following

CONSTITUTION.

ARTICLE I.

SECTION 1. The name and style of this Association shall be the AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.

ARTICLE II.

SEC. 1. The officers of the Association shall be a President, a First and Second Vice-President, a Secretary, and a Treasurer.

SEC. 2. The above-named officers shall be elected separately, by ballot, at a regular meeting, and a majority of all votes cast shall be necessary to a choice.

SEC. 3. The officers shall be elected for a term of one year, but in the event of the election being postponed shall continue in office until their successors shall be elected.

SEC. 4. Two tellers shall be appointed by the President to conduct the election and report the result.

ARTICLE III.

SEC. 1. It shall be the duty of the President to preside in the usual manner at all the meetings of the Association, and approve all bills against the Association for payment by the Treasurer.

SEC. 2. It shall be the duty of the Vice-Presidents, according to rank, to perform the duties of the President in his absence from the meetings of the Association.

SEC. 3. In case of the absence of both President and Vice-Presidents, the members present shall elect a President *pro tempore*.

SEC. 4. It shall be the duty of the Secretary to keep a full and correct record of all transactions at the meetings of the Association; to keep a record of the names and places of residence of all members of the Association, and the name of the road they each represent; to receive and keep an account of all money paid to the Association, and at the close of each meeting deliver the same to the Treasurer, taking his receipt for the amount; to receive from the Treasurer all paid bills, giving him a receipted statement of the same.

SEC. 5. It shall be the duty of the Treasurer to receive all money from the Secretary belonging to the Association; to receive all bills against the Association, and pay the same, after having the approval of the President; to deliver all paid bills to the Secretary at the close of each meeting, taking a receipted statement of the same; to keep an accurate book account of all transactions pertaining to his office.

ARTICLE IV.

SEC. 1. The following persons may become members of the Association by signing the Constitution, or authorizing the President or Secretary of the Association to sign for them, and pay the initiation fee of one dollar. Any person having charge of the Mechanical Department of a Railway known as "Superintendents," or "Master Mechanics," or "General Foremen," the names of the latter being presented by their superior officers for membership. Also, two Mechanical Engineers or the representative of each Locomotive Establishment in America.

SEC. 2. Civil and Mechanical Engineers and others whose qualifications and experience might be valuable to the Association may become Associate Members by being recommended by three active members. Their names shall then be referred to a committee, which shall report to the Association on their fitness for such membership. Applicants to be elected by ballot at any regular meeting of the Association, and five dissenting votes shall reject. The number of Associate Members shall not exceed twenty. Associate Members shall be entitled to all the privileges of active members excepting that of voting.

SEC. 3. Any persons who has been or may be duly qualified, and signs, or causes to be signed, the Constitution, as member of the Association, remains as such until his resignation may be voluntarily tendered.

SEC. 4. All members of the Association will be liable for such dues as may be necessary to assess to defray the expenses of the Association, and any

member who shall be two years in arrears for annual dues shall have his name stricken from the roll, and be duly notified of the same by the Secretary.

ARTICLE V.

SEC. 1. The regular meeting of the Association shall be held annually on the second Tuesday in May.

SEC. 2. Regular meetings shall be held at such place as may be determined upon by a majority of the members present at the previous meeting.

SEC. 3. An adjourned meeting may be held at any time and place that a majority of the members present at any meeting may elect.

SEC. 4. The regular hours of sessions shall be from 9 o'clock, A. M., to 2 o'clock, P. M.

SEC. 5. During the business sessions no communications shall be received or acted upon other than those pertaining to the business of the Association.

ARTICLE VI.

SEC. 1. This Constitution may be amended at any regular meeting of the Association by two-thirds vote of the members present.

Resolution passed at the Sixth Annual Meeting, Baltimore, May 1873.

Resolved, That no expense shall be incurred by committees except by the unanimous consent of the General Supervisory Committee, given in writing to the Chairman of said committees stating the amount to be expended.

NAMES AND ADDRESS OF MEMBERS OF THE AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.

NAME.	ROAD.	ADDRESS.
Anderson, H		51 Fifth av. Chicago.
Anderson, J. H	N. Y. B. & P. Rd	Providence, R. I.
Adams, G. Q	Q. M. & P. Rd	Kirksville, Mo.
Alden, H. A	C. C. & B & O. Rd	Brockville, Ont.
Britton, H. M	C. & W. V. Rd	Cincinnati, Ohio.
Brown, M. E.	Erie Rd	New York City.
Boone, J. M	P. Ft. W. & C. Rd	Ft. Wayne, Ind.
Baer, R. B	T. & N. O. Rd	Houston, Texas.
Bushnell, R. W	B. C. R. & M. Rd	Cedar Rapids, Iowa.
Brastow, L. C	L. & S. Rd	Wilkesbarre, Pa.
Bryant, Wm. H	Ft. W. & C. Rd	103 Jud st., Chicago, Ill.
Brown, H. L	Late Erie Rd	Paterson, N. J.
Blackall, R. C	A. & S. Rd	Albany, N. Y.
Boyden, G. E	B. H. & E. Rd	Boston, Mass.
Burroughs, A. P	M. & O. Rd	Marquette, Mich.
Brooks, H. G	Brooks Locomotive Works	Dunkirk, N. Y.
Brown, C. H	West. Div. D. L. & W. Rd	Utica, N. Y.
Britton, A. W	C. & W. V. Rd	Harrison, Ohio.
Blanchard, J. M		
Cullen, Wm	C. H. & D. Rd	Cincinnati, Ohio.
Cooper, W. E	Erie Rd	Hornersville, N. Y.
Chapman, N. E	C. & P. Rd	Cleveland, Ohio.
Cummings, S. M	P. Ft. W. & C. Rd	Allegheny, Pa.
Coolidge, G. A	F. Rd	Charlestown, Mass.
Connell, Thos	Box 488	Hornersville, N. Y.
Clark, D	L. V. Rd	Hazleton, Pa.
Cooper, H. L	H. & St. Joe Rd	Hannibal, Mo.
Church, Foster	T. & B. Rd	Troy, N. Y.
Collings, E	C. & A. Rd	Camden, N. J.
Colburn, R.	N. & W. Rd	Norwich, Conn.

NAME.	ROAD.	ADDRESS.
Calhoun, J. C.		
Cook, James	Danforth & Cook's Locomotive and Manufacturing Co.	Paterson, N. J.
Cushing, Geo		Chicago, Ill.
Curtis, Robert	P. C. & St. L. Rd	Columbus, Ohio.
Crockett, Jno. F.	B. L. & N. Rd	Boston, Mass.
Clark, Peter	N. R. R. of C.	Toronto, Can.
Child, Frank D.	Hinkley Locomotive Works	Boston, Mass.
Casscaddin, R. O.	C. R. I. & Pac. Rd	Trenton, Mo.
DeClercq, A. H.	In. & G. N. Rd.	Hearne, Texas.
Devine, J. F.	W. & W. Rd	Wilmington, N. C.
Drippes, Isaac	P. Rd	Altoona, Pa.
Davies, D. T	V. & M. Rd	Fitchburg, Mass.
Duncan, Wm		Worcester, Mass.
Dohoney, R. V.	A. & E. Rd	Annapolis, Md.
Eddy, Wilson	B. & A. Rd	Boston, Mass.
Elliott, Henry	O. & M. Rd	East Louis, Mo.
Edams, J. B	I. C. Rd	Amboy, Ill.
Evans, Thos	C. & F. Rd	Catasauqua, Pa.
Erwin, J. H	S. F. Div. L. Rd	Sheboygan, Wis.
Eastman, J. U	N. & C. Rd	Nashville, Tenn.
Ellis, J. C.	Schenectady Loco'tive Works	Schenectady, N. Y.
Eastman, C. L.	C. Rd	Concord, N. H.
Elder, Joseph	R. R. I. & St. L. Rd	Beardstown, Ill.
Elliott, C. C.	C. & N. W. Rd	Clinton, Iowa.
Ellis, W. H	P. & R. Rd	Catawissa, Pa.
Foster, W. L.	P. & E. Rd	Renovo, Pa.
Fry, Howard	Late Erie Rd	Susquehanna, Pa.
Flynn, J. H	W. & A. Rd	Atlanta, Ga.
Fuller, Wm	A. & G. W. Rd	Meadville, Pa.
Foss, J. M	C. V. Rd	St. Albans, Vt.
Fellows, Chas	Late L. S. & T. V. Rd	Cleveland, Ohio.
Faries, H. V	A. T. & Santa Fe Rd	Topeka, Kan.
Finlay, L.	C. & F. Rd	Little Rock, Ark.
Fields, W. A.	P. & O. Rd	Portland, Me.
Funk, J. S.	N. C. Rd	Marysville, Pa.
Gibbs, E. B	L. C. & L. Rd	Louisville, Ky.
Graham, Chas.	L. & B. Rd.	Kingston, Pa.
Glass, G. W.	A. V. Rd	Pittsburg, Pa.
Garfield, E	H. P. & F. Rd	Hartford, Conn.

NAME.	ROAD.	ADDRESS.
Garrett, H. D.	P. Rd.	West Philadelphia.
Gorman, T. G.	M. K. & T. Rd	Parson, Kan.
Grant, R. D.		
Griggs, W. H.	N. Y. &. O. M. Rd	Oswego, N. Y.
Griggs, Albert	W. & N. Rd.	Worcester, Mass.
Granger, W. E.	W. & B. R. Rd	Utica, N. Y.
Gassett, L. O.	L. S. & M. S. Rd.	South Cleveland, Ohio.
Gould, A	N. Y. C. & H. R. Rd	Rochester, N. Y.
Gould, F	M. K. & T. Rd	Sedalia, Mo.
Hipple, W. H.	Late T. & P. Rd	Marshall, Texas.
Hayes, S. J	I. C. Rd	Chicago, Ill.
Hill, E. O.	Erie Rd	New York City.
Holloway, J. W.	C. Mt. V. & D. Rd	Akron, Ohio.
Ham, C. T.	Buffalo Steam Guage Co.	Buffalo, N. Y.
Hayes, N.		
Hull, A. S.	C. V. Rd	Chambersburg, Pa.
Hudson, W. S.	Rogers Locomotive Works	Paterson, N. J.
Hibberd, A. W.	Jefferson City Iron Works	Jefferson City, Mo.
Hewitt, Jno	A. & P. Rd.	St. Louis, Mo.
Haynes, O. A.	St. L. & I. M. Rd	Carondelet, Mo.
Healy, B. W.	Rhode Island Loco'tive Works	Providence, R. I.
Hudson, J. M.		Huntington, W. Va.
Hollister, C. W.	Valley Rd	Hartford, Conn.
Hubbard, J. G.	Erie Rd	Buffalo, N. Y.
Hanford, Henry	Naugatuck Rd	Bridgeport, Conn.
Hodgman, S. A.	P. W. & B. Rd.	Wilmington, Del.
Hurd, R. F.	P. P. & J. Rd.	Pekin, Ill.
Hanglin, J. A.	Texas Pacific Rd	Marshall, Texas.
Johann, Jacob	T. W. & W. Rd	Springfield, Ill.
Jackson, Wm		Rome, N. Y.
Jackman, J. A.	C. A. & St. L. Rd	Bloomington, Ill.
Jones, Thomas	C. & F. Rd.	Catasauqua, Pa.
Jeffrey, E. T.	I. C. Rd.	Chicago, Ill.
Johnson, J. D.	C. & A. Rd.	Chicago, Ill.
Kinsey, J. I.	L. V. Rd.	Easton, Pa.
Kelly, Joseph	P. & W. Rd	Providence, R. I.
Kerr, Thomas	C. & A. Rd.	Bordentown, N. J.
Keeler, Sanford	F. & P. M. Rd	East Saginaw, Mich.
Kidder, B. H		Buffalo, N. Y.
King, Robert	C. C. & A. Rd	Columbia, S. C.

NAME.	ROAD.	ADDRESS.
Kilby, G. S.	C. & P. Rd	Lyndonville, Vt.
Losee, T. V.	I. B. & W. Rd	Urbana, Ill.
Little, H. A.	2043 Tower street	Philadelphia, Pa.
Losey, J.	L. N. A. & C. Rd	New Albany, Ind.
Lewis, C. M.	N. C. Rd	Baltimore, Md.
Lauder, J. N.	N. Rd	Concord, N. H.
Landis, H. D.	B. & S. S. Rd	Bellfonte, Pa.
Leech, H. L.	Hinkley Locomotive Works	Boston, Mass.
Lamb, J.		Keokuk, Iowa.
Logan, P. A.	N. B. Rd	Fredricton, N. B.
Lininger, W.	P. V. & C. Rd	Pittsburg, Pa.
Lingle, Thomas	C. & O. Rd	Richmond, Va.
Lewis, W. H.	M. & E. Div. D. L. & W. Rd.	Hoboken, N. J.
Losey, Fred. C.	120 Park avenue	Jackson, Mich.
Lannon, Wm.	W. M. Rd	Union Bridge, Md.
Ladd, J. J.	S. & I. S. E. Rd	Pana, Ind.
Munro, J. C.	St. P. & P. Rd	St. Paul, Minn.
Moore, S.	P. Ft. W. & C. Rd	Allegheny, Pa.
Mulligan, J.	C. R. Rd	Springfield, Mass.
Meier, E. D.	26 North Main street	St. Louis, Mo.
Mitchell, A.	W. Div. L. V. Rd	Wilkesbarre, Pa.
McDowell, R.	B. D. Rd	Lambertville, Pa.
McKenna, J.	I. P. & C. Rd	Peru, Ind.
McAllister, W.	W. J. Rd	Camden, N. J.
McFarland, James	M. & M. Rd	Montgomery, Ala.
McFarland, John	R. & D. Rd	Richmond, Va.
McCrum, J. S.	M. R. Ft. S. & G. Rd	Kansas City, Mo.
Maynes, A. G.	S. R. & D. Rd	Selma, Ala.
McVay, John	W. R. R. of A.	Montgomery, Ala.
Montgomery, Jas.	L. & N. Rd	Bowling Green, Ky.
Morse, G. F.	Portland Locomotive Works	Portland, Me.
Marsh, E. H.	W. N. C. Rd	Salisbury, N. C.
Martin, J. W.	G. T. Rd	Portland, Me.
Mead, L. T.	W. W. Rd	Hudson, Wis.
Morgan, John B.	C. D. & V. Rd	Danville, Ill.
Morris, C. R.	Housatonic Rd	Falls Village, Conn.
Metzer, Charles	L. C. & L. Rd	Louisville, Ky.
Noyes, Warren	East. Div. G. T. Ry.	Gorham Station, N. H.
Ortton, John	G. W. Ry. of Canada	Hamilton, Ont.
Osborn, Ezra	Grant Locomotive Works	Paterson, N. J.

NAME.	ROAD.	ADDRESS.
Perry, F. A	C. & A. Rd.	Keene, N. H.
Perry, G. W	Late P. W. & B. Rd	Wilmington, Del.
Pierce, E	P. C. & St. L. Rd	Dennison, Ohio.
Parks, W. M	T. B. Rd	Taunton, Mass.
Philbrick, S. M	L. L. & G. Rd	Lawrence, Kansas.
Perrin, P. J	Taunton Locomotive Works	Taunton, Mass.
Prescott, A. J	C. Rd	Catawissa, Pa.
Peddle, C. R	St. L. V. & T. H. Rd	Terre Haute, Ind.
Philbrick, J. W	M. C. Rd	Waterville, Maine.
Prescott, G. H	P. C. & St. L. Rd	Logansport, Ind.
Purves, T. B	W. D. of B. & A. Rd	Greenbush, N. Y.
Place, T. W	Ill. C. Rd	Waterloo, Iowa.
Ray, W. F	T. W. & W. Rd	Ft. Wayne, Ind.
Richards, George	B. & P. Rd	Boston, Mass.
Roop, F	N. P. Rd	Philadelphia, Penn.
Robinson, W. A	G. W. Ry. of Canada	Hamilton, Canada.
Robinette, J. T	S. S. Rd	Petersburg, Va.
Rowley, W. D	K. C. St. Joe & C. B. Rd	St. Joe, Mo.
Ross, Anthony	M. & C. Rd	Memphis, Tenn.
Robb, W. D	E. & P. Rd	Elizabethtown, Ky.
Rennie, D. P	L. & N. Rd	Louisville, Ky.
Stevens, G. W	L. S. & M. S. Rd	Elkhart, Ind.
Somers, A. H	P. Ft. W. & C. Rd	Valparaiso, Ind.
Skidmore, J	T. N. & G. S. Rd	Nashville, Tenn.
Shaver, D. O	Pennsylvania Rd	Pittsburg, Pa.
Smith, W. F	C. C. C & I. Rd	Cleveland, Ohio.
Sellers, Morris	Air Brake Company	Pittsburg, Pa.
Setchel, J. H	L. M. Rd	Cincinnati, Ohio.
Sellers, L. H	P. & L. Rd	Pensacola, Florida.
Smith, W. T	P. & E. Rd	Erie, Pa.
Sedgley, J	L. S. & M. S. Rd	Cleveland, Ohio.
Strong, W. M	N. Y. & H. Rd	New York City.
Sanborn, A. J	I. & St. L. Rd	Mattoon, Ill.
Stearns, W. H	C. R. Rd	Springfield, Mass.
Sterk, F	V. & T. A. M. & O. Div.	Lynchburg, Va.
Smith, J. Y	Locomotive Builder	Pittsburg, Pa.
Stewart, R. C		
Smith, W. B	S. C. Rd	Charleston, S. C.
Stewart, C. E	Panama Rd	59 Wall st., N. Y. City.
Slingland, N	Western Rd	Hartford, Conn.

NAME.	ROAD.	ADDRESS.
Sprague, H. N	Porter, Bell & Co	Pittsburg, Pa.
Sechler, J. F	N. Y. & O. M. Rd	Wortendyke, N. J.
Steinberger, Sam'l	J. M. & I. Rd	North Madison, Ind.
Salisbury, L. B	St. L. & S. E. Rd	Mt. Vernon, Ill.
Schlacks, H	I. C. Rd	Chicago, Ill.
Stratton, G. W.	Pennsylvania Rd	Altoona, Pa.
Towne, L. N	H. & St. Joe Rd	Hannibal, Mo.
Thompson, C. A	L. I. Rd	Hunter's Point, L. I.
Thompson, John	Eastern Rd	East Boston, Mass.
Thompson, John	P. Ft. W. & C. Rd	Crestline, Ohio.
Turreff, W. F	L. S. & T. V. Rd	Black River, Ohio.
Towne, H. A	N. P. Rd	St. Paul, Minn.
Taylor, J. K	O. C. & N. Rd	Boston, Mass.
Templeton, Thos	P. Rd	Battle Creek, Mich.
Tier, G. H	Toledo Div. L. S. & M. S. Rd	Norwalk, Ohio.
Thornton, M	M. & B. Rd	Macon, Ga.
Tull, C. H	N. L. & T. Rd	Monroe, La.
Thompson, Archie	O & M. Rd	Seymour, Ind.
Underhill, A. B	B. & A. Rd	Boston, Mass.
Van Vetchen J	Erie Rd	Port Jarvis, N. Y.
Van Tuyl, A.		Urbana, Champaign Co., Illinois.
Van Buskirk, W. G	D. & C. Rd	Fishkill, N. Y.
Walsh, Thos	M. & O. of L. & N. Gt. So. Rd.	Memphis, Tenn.
Warren, B	St. L. A. & T. H. Rd., V. B. & I. Division	St. Louis, Mo.
Wallace, W. L	L. B. & S. I. Div. S. & M. S. Rd	Buffalo, N. Y.
Wallace, H. S	C. & H. V. Rd	Columbus, Ohio.
Woods, Horace E	C. R. I. & Pac. Rd	Rock Island, Ill.
Whitney, H. A	Intercolonial Rd	Moncton, N. B.
Wells, Reuben	J. M. & I. Rd	Jeffersonville, Ind.
Wright, N	A. & G. W. Rd	Cleveland, Ohio.
Wade, R. D	N. C. Rd	Company Shops, N. C.
Wiggins, J. E	B. H. & E. Rd	Boston, Mass.
Waite, F. A	B. & M. Rd	Boston, Mass.
Woodcock, W	Central Rd	Elizabethport, N. J.
White, J. L	E. & C. Rd	Evansville, Ind.
Waddy, J. E	O. A. & M. Rd	Alexandria, Va.
Williams, E. H	Baird & Co., Loco. Builders	Philadelphia, Pa.

NAME.	ROAD.	ADDRESS.
Waugh, L. H	K. P. Rd	Armstrong, Kansas.
Weaver, D. S	E. K. Rd	Hunnewell, Ky.
Whitworth, John	I. S. N. & P. Rd	Norfolk, Va.
Wood, Matt. P	C. & T. H. Rd	Terre Haute, Ind.
Walls, Martin	P. & E. Rd	Sunbury, Pa.
White, Philip	C. & P. Rd	Wellsville, Ohio.
Woodruff, T. B	Central Rd. of Iowa	Eldora, Iowa.
Wilson, Wm	C. B. & Q. Rd	Galesburg, Ill.
Young, L. S	C. C. C. & I. Rd	Cleveland, Ohio.

ASSOCIATE MEMBERS.

Bement, W. B	21st and Callowhill streets	Philadelphia, Pa.
Evans, W. W	63 Pine street	New York.
Forney, M. N	Railroad Gazette	73 Broadway, New York.
Holly, A. L		Troy, N. Y.
Lilly, J. O. D		Indianapolis, Ind.
Miles, F. B	Ferris & Miles	Philadelphia, Pa.
Morten, Henry	Stevens Institute	Hoboken, N. J.
Nott, Gordon H		Boston, Mass.
Rogers, J. G		Madison, Ind.
Sellers, Coleman		Philadelphia, Pa.
Thurston, R. H	Professor at Stevens Institute	Hoboken, N. J.
Wheelock, Jerome		Worcester, Mass.

ORDER OF BUSINESS.

1. Reading the Minutes of previous meeting.
2. Calling the Roll of Members.
3. Signing the Constitution.
4. Report of Secretary.
5. Report of Treasurer.
6. Report of Committees appointed at a previous meeting.
7. Election of Officers.
8. Appointment of a Committee to suggest Subjects for Consideration.
9. Appointment of Miscellaneous Committees: on Finance, Printing, and place for holding next Annual Meeting.
10. Report of Committee to suggest Subjects for Consideration.
11. Appointment of Committees to report upon the Subjects suggested for Consideration.
12. Unfinished Business.

[Signed,]

H. M. BRITTON,
N. E. CHAPMAN,
WM. A. ROBINSON,
J. H. SETCHEL,
} *Committee.*